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Journal

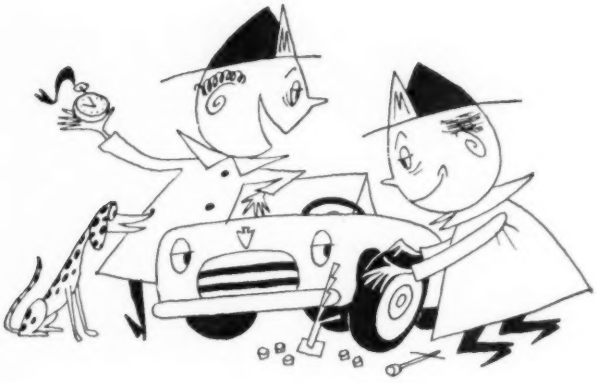
VOL. 44 • NO. 10

AMERICAN WATER WORKS ASSOCIATION

In this issue

Intakes on Variable Streams	Lischer, Hartung
Steel Pipe Coatings	Burnett, Masin
Ductile Iron—A New Material	Haller
Soil Temperatures	Legget, Crawford
Taste of Fluoridated Water	Cox, Nathans
Fluoridation Census	Task Group Report
Fluoridation and Dental Research	Frye, Hill
Pumping Station Problems	Dobbin
Sealing Abandoned Wells	Committee Report
Deep Well Specifications—Addendum	AWWA A100–52
Steel Pipe Flange Specifications	AWWA C207–52T

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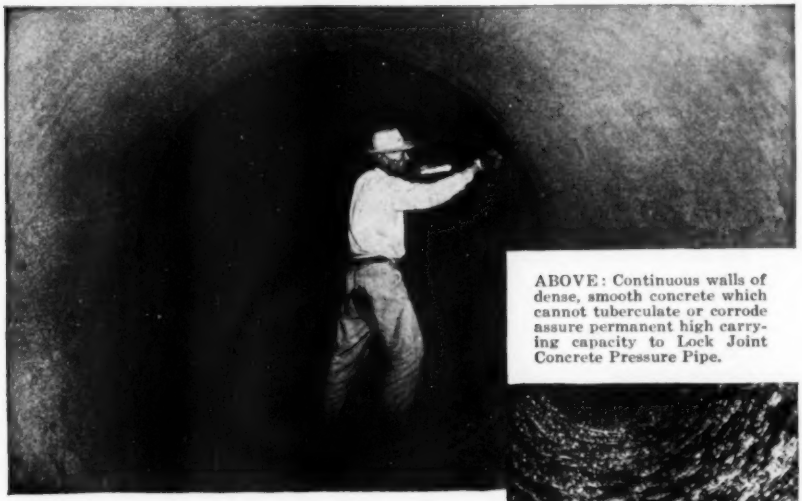
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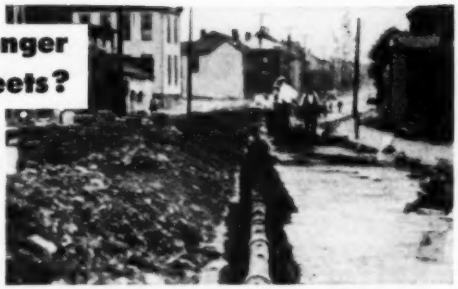
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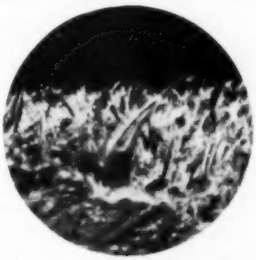
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Vol. 44 • No. 10

Contents

Intakes on Variable Streams.....VANCE C. LISCHER & HERBERT O. HARTUNG 873

Developments in Tests of Coatings for Steel Pipe
GRAYDON E. BURNETT & CHARLES B. MASIN 893

Ductile Iron—A New Engineering Material for Water Works Construction
C. T. HALLER 912

Soil Temperatures in Water Works Practice....R. F. LEGGET & C. B. CRAWFORD 923

A Study of the Taste of Fluoridated Water
GERALD J. COX & JESSICA W. NATHANS 940

Natural and Applied Fluoridation Census: Supplemental Report
TASK GROUP E5-10 943

Correction 946

Water Fluoridation and Dental Research.....HORACE R. FRYE & IDEN N. HILL 947

Problems in the Design and Operation of a Booster Pumping Station
R. L. DOBBIN 957

Preparation of Recommended Procedure for Sealing Abandoned Wells
COMMITTEE E4A 961

Standard Specifications for Deep Wells—Addendum.....AWWA A100-52 965

Tentative Standard Specifications for Steel Pipe Flanges....AWWA C207-52T 969

Departments

Officers and Directors..... ii, iv
Percolation and Runoff..... 1
The Reading Meter..... 22, 86
Membership Changes..... 30
Condensation..... 42
Service Lines..... 96
Coming Meetings..... 98
Classified Index..... 102

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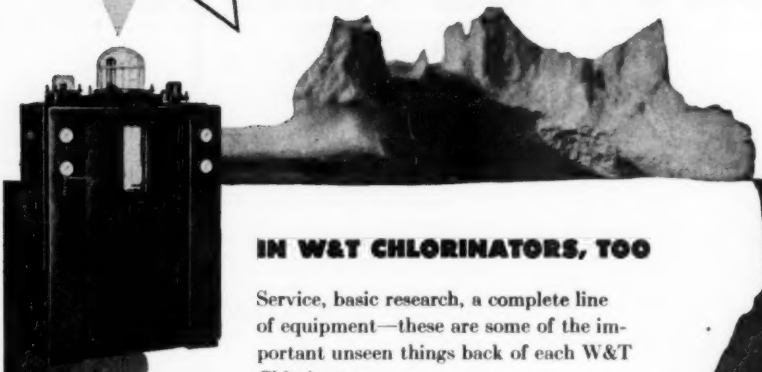
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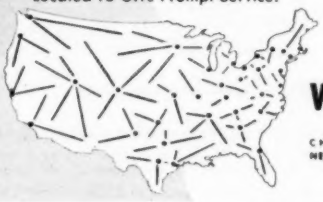
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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 44 • OCTOBER 1952 • NO. 10

Intakes on Variable Streams

By Vance C. Lischer and Herbert O. Hartung

A paper presented on May 8, 1952, at the Annual Conference, Kansas City, Mo., by Vance C. Lischer, Horner and Shifrin, Cons. Engrs., St. Louis, Mo., and Herbert O. Hartung, Production Dept. Engr., St. Louis County Water Co., St. Louis, Mo.

A DEPENDABLE source of water supply is the prime requisite of a water system. When the source of supply must be a variable stream, careful planning and engineering are necessary to make it dependable. No disasters in water supply operation are more serious or more difficult and time consuming to correct than many kinds of intake failures. Intake failures are generally attributable to lack of consideration for the extreme vagaries of nature which are never more manifest than on variable streams.

Variability in a stream not only refers to fluctuations in flow and level, but also to the natural habit of a stream to meander and change its shoreline, to its power to transport heavy loads and the resultant shifting of the bottom of the stream, and to abrasion problems which result from the presence of sand and silt in the water being pumped.

Incidental to these major problems on variable streams, and of much greater importance to the designer and operator, are the problems in cold climates resulting from ice, the problems due to drift and floating material, and perhaps even navigation problems. The other problems of water quality, pollution, and treatment are not discussed, as the scope of this paper is confined to the intakes or the means of extracting water from variable streams.

Unstable Channel

Meandering rivers in broad, flat flood plains with deep alluvium present the most difficult problems for the intake designer. Unless the water user is prepared for the great expense entailed by dikes, jetties, and channel protection, he may find that the river channel will silt up and move away from a costly installation or may even endanger it by cutting behind it. Only large cities can afford such extreme expense. Careful thought must be given to site selection, and the site should have a long history of stability.

Although the navigation and flood control improvements of the Army Corps of Engineers on major streams in the United States have generally benefited intake installations, there are examples of a channel being deliberately moved away from existing intakes, thus creating serious problems and causing towns to build new intakes at additional expense. In general the intake site should be chosen on the outside bank of a well established river bend, a point at which the river is usually swiftest and deepest. The inside of a bend is generally shallow and has broad flat sand bars. If a site is available at which the river runs against a rock bank, a reliable intake can generally be built. Sufficient depth of water for extreme low water must be assured, however.

Silt and Bed Load

Besides the load of silt carried in suspension by flowing streams, there is also a constant movement of heavier material on the bed of the stream. Both of these sources of solids can be a problem in intake structures. The intake must be designed so that channels, conduits, or intake openings will not silt up or be obstructed by deposits of bed load. A serious problem of abrasion of mechanical equipment and pumps is frequently experienced in intakes on variable streams, making it difficult to maintain pump efficiency. Some of the trouble due to abrasion can be avoided by careful intake design and proper pump selection. Large amounts of sand and heavy solids will cause trouble in purification basins and may even necessitate the installation of grit removal facilities.

Cold Weather

Winter problems, too, are important to the designer of an intake on a variable stream. The intake structure must be massive enough to resist the thrusts of ice jams. The intake openings must be deep enough to avoid taking in slush ice which may run as deep as 6 to 8 ft in the stream. The piping and equipment must be protected against freezing. Frazil and anchor ice may be problems, but the problems resulting from floating ice are the most serious. In colder areas, where rivers freeze over every year winter problems may be less acute than in areas where periods of extreme cold bring floating ice.

High Water

The problems of high water and flood are common. Intake failures under such conditions generally result from failure to consider properly the flood potentiality of a stream. A stream stage record of even 100 years is inadequate in terms of geologic time concepts.

The same care should be given to the selection of the safe flood height of the intake structure as is given to the determination of the spillway capacity of a dam. The extent to which it is possible for floods to exceed previously considered safe levels was demonstrated in the floods of 1937 at Cincinnati, 1951 at Kansas City, and 1952 at Omaha. At Cincinnati, the previous maximum stage was exceeded by 8.9 ft, at Kansas City by 5 to 8 ft, and at Omaha by 5.5 ft.

In the long-term planning that is essential to the design of public water supplies, consideration must be given to the changes which man is making in watersheds and stream channels that affect the rate of runoff and the stream channel capacity. Those changes which encourage floods are brought about by deforestation, agricultural uses of land which increase runoff and erosion, mining and industrial operations which

expose the soil, and, on small watersheds, urban developments which change the percentage of impervious area. Further aggravation of the problem is brought about by man-made structures, such as bridges, docks, and levees, which confine the channel and create higher flood crests.

The few efforts made thus far in flood prevention by the construction of dams and by better land use have been of negligible consequence in the control of maximum flood levels on major streams. The designer has no choice but to provide a liberal margin of safety in establishing the flood protection level of the intake. The breaking of previous records at Cincinnati, Kansas City, and Omaha should serve as a warning and perhaps a guide.

Low Water

Low water conditions have an important bearing on intake design. The intake must be capable of extracting the necessary quantity at the lowest stage which might occur. The depth of the lowest intake opening must be materially lower if the stream is subject to floating ice and extremely cold climatic conditions. If a minimum intake submergence of 3 ft is adequate in warm climates, 8 to 10 ft and preferably more submergence may be required in cold climates. Hence, the season of the year in which low water occurs is an important consideration.

Extreme low-water stages of most of the large midwestern streams occur during the winter because of ice jams upstream and the complete dependence for flow upon ground water—for example, the 91-year records for the St. Louis gage on the Mississippi show a summer low of − 4.1 ft and a winter low of − 6.1 ft.

Ground water is the only important contribution to stream flow in determining low-water stages. In a large watershed, such as that of the Missouri and the Mississippi, some surface water is likely to be included in the flow at all times, but the effect of previous rainfall deficiency will be the dominant factor in establishing low stages, as illustrated by the occurrence of the lowest summertime stages of the Mississippi River at the St. Louis gage after the drought years of 1934 and 1936. The low stage was − 3.0 in the summer of 1934 and − 4.1 in the summer of 1936.

In the design of an intake, stream stage records are the only reliable source of data for determining extreme low-level conditions. Site observations may be helpful but it is necessary to be extremely conservative in establishing the lowest operating level of the intake to allow for deficiencies of record information and for the variability of nature.

Frequently, and particularly if small streams must be the source of supply, it may not be practical to provide sufficient intake depth in the natural stream. A depression in the natural stream bed to provide the requisite depth is impractical because of bed load siltation which could not be avoided. A low dam may be the only means of securing sufficient intake depth. Such a dam may be designed to be completely submerged during flood periods or may be designed with proper spillway capacity. As not more than 8 to 10 ft may be required, a low dam of such height can be self-scouring during periods of high water. Thus deposits of sand and gravel will not make the intake inoperative.

Variable Head

If an intake serves purification works located in an alluvial bottom, the variation in head on the intake

pumps caused by fluctuations in river level may constitute a problem in pump selection and may be an important consideration in intake design. Variations in level between extreme high and low stages of 30 to 50 ft are not uncommon. If the average static head is of the order of 30 to 40 ft, static pumping heads may vary from 10 to 60 ft. The selection of pumping units to operate over this range at good efficiency and without cavitation is difficult.

In selecting the pumping units, data on the duration or length of time that various river stages are experienced are necessary if maximum average efficiency is to be achieved. Knowledge of the seasonal pattern and extremes is also necessary to determine the intake capacity requirements that are dictated by the seasonal variation in water demand. Such information is generally available from the United States Weather Bureau, from the state water survey or the U.S. Geological Survey. A typical stage-duration curve for 88 years of record from the St. Louis gage is given in Fig. 1. This curve is constructed from tabulations made by the Army Corps of Engineers. Information of this character is necessary for the intelligent design of intake structures.

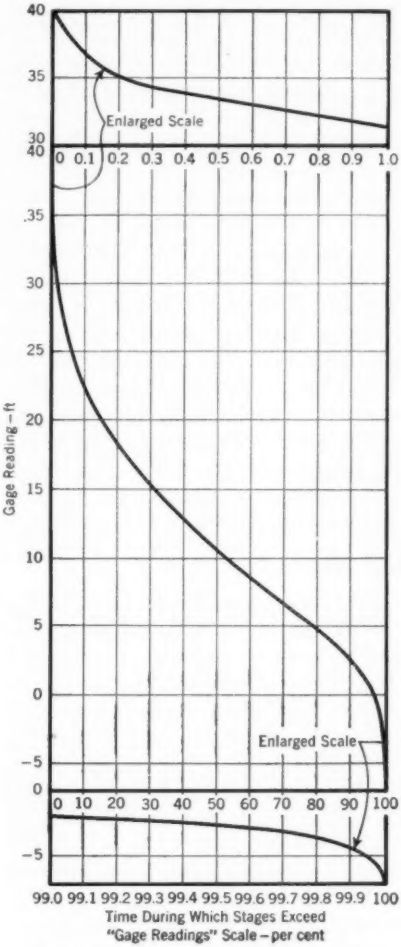


Fig. 1. Stage-Duration Curve of Mississippi River

The data were obtained over a period of 88 yr at the St. Louis gage. Zero on the "Gage Reading" scale was taken at 379.94 ft mean sea level.

Screens

The nature of floating material in a stream has an important bearing on intake design. A strainer or screen is necessary to protect the pump and the purification facilities. In order to minimize the possibility of clogging of the screen or strainer, the openings should be as large as is consistent with the capacity of the pump to pass solids and the purification facilities to handle them. For low-head pumps of 10-in. pipe size and larger, strainer openings of 1½ to 2 in. in diameter should not result in difficulties with pumping equipment. If the intake pumps are smaller, care must be taken to provide the largest possible screen opening. The manufacturer can generally supply information on the largest sphere which

his pump will pass. The character of solids and of the purification facilities will determine the extent of screening required to avoid difficulties with these facilities. In general, most material that is likely to be taken in will soon become waterlogged and be removed by the sludge-handling equipment.

In order to minimize clogging and to conserve head, it is essential that the velocity of flow through screen or strainer openings be relatively low. The velocity, which is based on net area, can be as high as 1 to 2 fps for coarse bar screens having 1½-in. spacing and larger and should be as low as ½ fps for ½-in. mesh screens.

Screens or strainers that are likely to become clogged should be capable of being cleaned. When the material that is producing the clogging can be handled in the purification process, consideration should be given to the use of coarser screens because screen cleaning is a costly nuisance. If the intake opening is located at a point subject to high channel velocities in the stream and if back-flushing can be accomplished, it should be possible to eliminate the use of mechanically cleaned screens and to use only a coarse bar screen in front of the intake gate or opening. Frequently the small amount of reversal of flow that results from a pump shutdown is adequate to permit solids adhering to the screen to be released and to be carried away by the current.

If the purification processes include coagulation, sedimentation using mechanical clarifiers, and filtration, it is doubtful whether the use of ½ to 1-in. mesh screening can be justified. Elaborate investments in screening facilities are required if clear untreated lake water is used as a direct source with chlorination the only treatment or if water is used untreated for cooling and similar processing requirements.

Frequently fish and other large living organisms enter the intake openings. It is difficult to conceive of an intake screen that would be practical and still strain out all such living organisms. Actually, from a public health standpoint, they would be of little sanitary significance in a modern plant if allowed to reach the purification works either dead or alive in the numbers that are likely to be encountered in most streams. If dead, they would be quickly removed in the sludge removal process and if alive, they could not pass through the filters. There is certainly little difference from the public health standpoint between dead organisms in the river and in the treatment works. In short there is little justification for providing screens small enough to catch all the fish that might be encountered unless there is specific experience to indicate they can be encountered in sufficiently large numbers to constitute a purification or health problem.

If floating material is likely to include heavy loads of drift, intake structures protruding into the stream must be designed to withstand the forces resulting from such loads. If the stream is used for navigation, the possibility of impact from boats or barges that are out of control must also be considered.

Legal Problems

In arid regions, prior rights to the flow in the stream must be recognized before additional water can be taken. If the stream flow is low, the water user must recognize the rights of persons downstream to use of the water in the stream and must be prepared to establish and to protect his legal right to the water.

If the river is under the control of the Army Corps of Engineers, such as

the Missouri, Mississippi, Ohio, and others, it is necessary to obtain a permit to construct an intake and to extract water from the river. It must be recognized that a riparian owner on such a river has no right to land below an arbitrary water level described as the "ordinary low-water line." Usually this line must be established by legal procedure. Of equal importance to an intake designer is the "ordinary high-water line." This line establishes the width of the navigable channel on navigable streams over which the federal government has jurisdiction through the Army Corps of Engineers. It is more easily defined than the ordinary low-water line—and is generally a few feet short of bank full level.

Nature gives no guarantee, of course, that the shoreline or even the land on which the structure is founded will be maintained to continue the useful function of the intake. Even worse, the government can move the channel away from the intake and thus nullify the entire investment, without recompense to the owner. The intakes at St. Charles, Mo., and Council Bluffs, Iowa, are past examples. Before planning an intake on any major stream, it is desirable to ask governmental agencies about any planned channel improvements.

Intake Types

The means of extracting water from variable streams are as varied as the imagination of man. Intake design is influenced by the characteristics of the stream and shore line, the quantity of water desired, economic considerations, and the degree of reliability required.

Intake Towers

Intake towers are defined as intake structures generally located in midstream with a gravity pipe or tunnel leading to the intake pumping station which is located on or near the shore. Intake towers were formerly used extensively. A part of the intake facilities of the Chain of Rocks Plant of St. Louis is of this type. Two intake towers are in use in addition to a shore intake. The conduits from the towers to the wet well are tunnels in rock.

Intake towers will generally have several gated openings for admitting water. The openings used at any particular stage will depend on bed load movement in the stream. Intake towers and their associated underwater conduits or tunnels are costly and hence their use is confined to large plants. They require a fairly stable channel and the construction of the conduit is simplified if a rock tunnel can be used. An important disadvantage is their inaccessibility during periods of heavy floating ice and the inconvenience of having to reach them by boat. For ordinary operation this disadvantage can be offset by using remote-controlled gate operators. Emergency maintenance may require a trip to the tower during unsatisfactory river conditions, however.



Fig. 2. Shore Intake at Howard Plant in St. Louis

Shore Intakes

A shore intake is the most commonly used type for large intakes. It consists of a massive structure with a vertical or slightly inclined wall at the river edge. This wall has gated openings at several depths for selective intake of water. Coarse bar screens, 3- to 4-in. spacing, are used in front of the gates and revolving screens are sometimes located in a well behind the gates. The most notable examples of this type of intake generally include as part of the structure a dry well in which horizontal, volute type centrifugal pumps are installed. The intake at the Howard Bend Plant in St. Louis is an outstanding example (Fig. 2).

If the dry wells are built as a part of the shore intake, problems of uplift and flotation are encountered. The structure must have sufficient mass to resist flotation under extreme flood conditions. Vertical wet well pumps have been used to minimize the expense of providing the required mass or piling to resist uplift and flotation.

Submerged Intake Cribs

The use of submerged intake cribs comparable to those used in clear lakes deserves only passing mention because of their limited application to river intake problems. Such intakes consist of a submerged timber or concrete box or crib with a bottom- or side-connected pipe running to the shore. Owing to bed load and siltation problems, it can rarely be used in variable streams.

Movable Intake Pumps

If the river is meandering, has an unstable bottom, or a water level that is subject to appreciable variation, the movable intake pump is frequently used. Movable intakes are structures and pumps that may be routinely moved to correspond to changes in the river. These designs usually have the advantage of low first cost in comparison to the fixed installations required under similar conditions of moving river bottom and changing water elevation. The low first cost, however, must usually be balanced against the operating

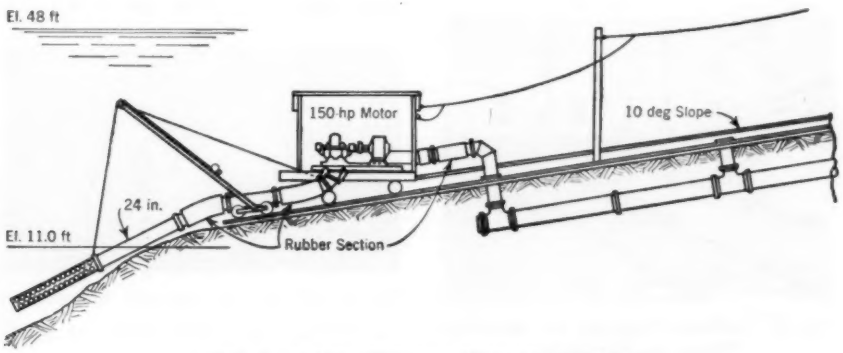


Fig. 3. Intake Pump on Movable Carriage

The installation shown is at the St. Louis County Water Co. Plant on the Missouri River. The pumphouses are built over railroad type wheels which roll upon a railroad track.

costs entailed each time a pump or structure is moved. On the other hand, the movable intake design frequently represents a very reasonable operating investment when weighed against the prohibitive cost of caissons or submarine foundations required in fixed installations.

Intake Pumps on Movable Carriages

Sometimes a river bank can be shaped, paved, and made stable to form an incline extending from the river bottom to a point above high water. Intake pumps on wheels or movable carriages which can be moved up or down the incline often constitute a low-cost, feasible intake. This type intake is especially adaptable if inclines can be formed on river bank levees that have been made stable by riprapping or revetment work and that are near the water's edge, but have soil-bearing conditions that preclude construction of heavier, fixed intakes.

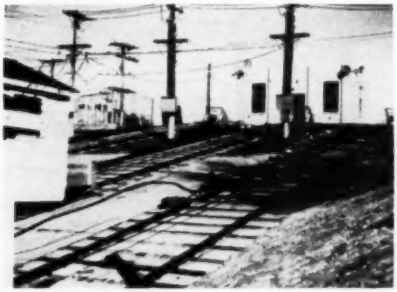


Fig. 4. Inclined Roadbed for Movable Pumps on Carriages

The tracks have either a 6- or 7-ft gage and are laid upon an approximately 10 per cent inclined roadbed.

Typical of this type of intake are the movable pumphouses and pumps at the St. Louis County Water Co. on the Missouri River (Fig. 3). Pumphouses, each containing a 16-in. or larger pump, are mounted on wheels which roll upon a railroad track. The tracks have either a 6- or 7-ft gage, and are laid upon an approximately 10 per cent inclined roadbed at right angles to the water edge and extending from extreme low-water elevation to the top of a levee above maximum flood elevation, as shown in Fig. 4. These pumphouses can be moved up or down the incline to follow the level of the water in the river. When the river water elevation is receding, the pumphouses are lowered to prevent pump suction lifts from becoming too great; when river water elevations are rising, the pumphouses are pulled up the incline to prevent flooding of the pumps.



Fig. 5. Winches for Moving Pumphouses

The winches are solidly anchored at the top of the incline.

Pumphouses are moved by a winch which is solidly anchored on top of the incline (Fig. 5) through a wire cable attachment. The winch is usually operated by a portable type gasoline motor but it can be operated by hand cranking using four to five men.

Suction piping for each pump extends from a point beneath the pumphouse floor into the river. The suction piping is attached to the pumphouse and moves up and down the incline with the pumphouse. Silting in of the suction strainer on the end of

the suction pipe is not a serious problem with this type intake because the suction strainer is moved to a different location each time the pump is moved up or down the incline. Heavy bed loads are also avoided because, during high stages, water is extracted near the river surface.

A pump discharge header parallels the rails on the pump incline. Flanged openings into this header are provided at several elevations to receive the pump discharge. Each time the pumphouse is moved, the discharge piping from the pump is reconnected to one of these flanged openings corresponding to the new elevation of the pump. A flexible rubber sleeve in the pump discharge piping facilitates easy bolting and unbolting to these flanged openings.

Power leads to the pump must also be disconnected and reconnected to an overhead power line each time the pumphouse is moved. The power line is parallel to the railroad rails and the poles are high enough for all cross arms to remain above high water even at the lower end of the incline. Power leads are attached to the overhead wire by means of simple slip-on and clamp connectors which can be attached or removed in a few moments.

The total time elapsed in moving a pumphouse containing a 16-in. or larger pump from one location to its next location higher or lower—approximately 5 ft difference in elevation—is about 3 hr, and normally requires a crew of three men. Each intake pump is designed to operate with a 15-ft suction lift.

This type of intake requires some extra operating attention during times of severe cold and icing of the river. The discharge pump piping can be adequately insulated and heated against freezing; the suction piping at the

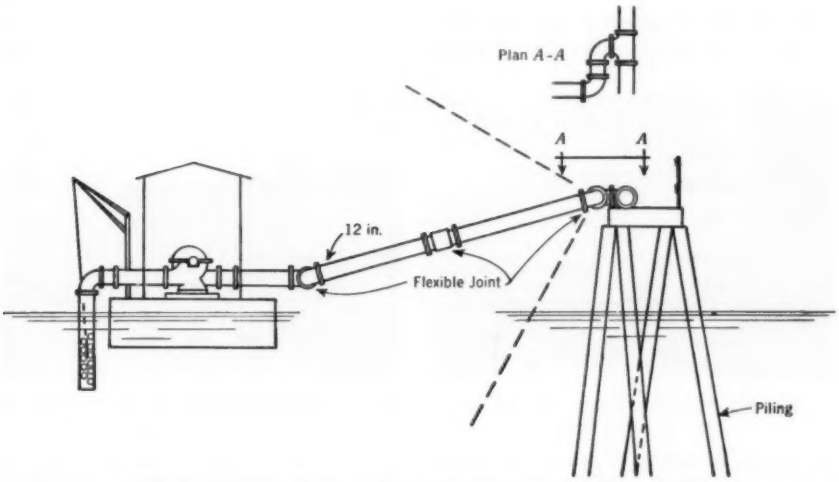


Fig. 6. Intake Pump on Floating Barge at St. Charles, Mo.

Discharge connection from the barge is made into one of several connections on a pipeline header laid on a dike extending into the river channel.

point of entry into the river, however, occasionally requires some additional protection to prevent freezing and damage from floating ice cakes.

Because the pumps are always above river level, they are always operated with a suction lift. Provision for priming the pumps is a requisite design condition. An automatic priming system is provided by the St. Louis County Water Co. for its pumps.

Floating Pumps

If both the river bank and the river bottom shift frequently, the floating type intake is sometimes applied. Intake pumps are installed upon a barge which can be moved with the changing river channel. Pump suction can be taken from an opening through the barge or the suction piping can be extended over the side of the barge. Both horizontal and vertical pumps have been used on such barges. Discharge pump piping is connected through flexible connections to a pipeline header which is usually carried from the shore to the barge on high piling or upon a rock-filled dike. If river bottom conditions permit, the pipeline can also be extended to the floating barge by laying the pipe in a dredged trench deep in the river bottom and terminated in a cluster of piling at the barge location. Operating power can be obtained through an electric cable or by diesel engines.

A floating barge intake was built at St. Charles, Mo. (Fig. 6 and 7) after the channel improvement of the Missouri River left the shore intake stranded behind a sand bar. The barge is moved in and out from the normal river bank along a dike as the river changes in width. Discharge connection from the barge is made into one of several connections on a pipeline header laid on a dike extending into the river channel. As sand bars form and threaten to silt in the suction piping, the barge is moved into deeper water.

The floating intake pump design results in a constant suction lift regardless of river levels. Barge location changes are required because of a moving river channel and the formation of sand bars. Such a location change is



Fig. 7. Floating Barge Intake at St. Charles, Mo.

The barge is moved in and out from the normal river bank along a dike as the river changes in width.



Fig. 8. Floating Barge Intake of Missouri Portland Cement Co.

The intake is located on the Missouri River at a location protected by timber dikes.

required several times each year at St. Charles and can be made within two hours by two or three men if the river is free of ice.

An icing river somewhat handicaps the movement of the barge to a different location. When a required location change happens to correspond with a frozen river, ice saws and picks are used to open up the necessary path to move the barge into a safe location.

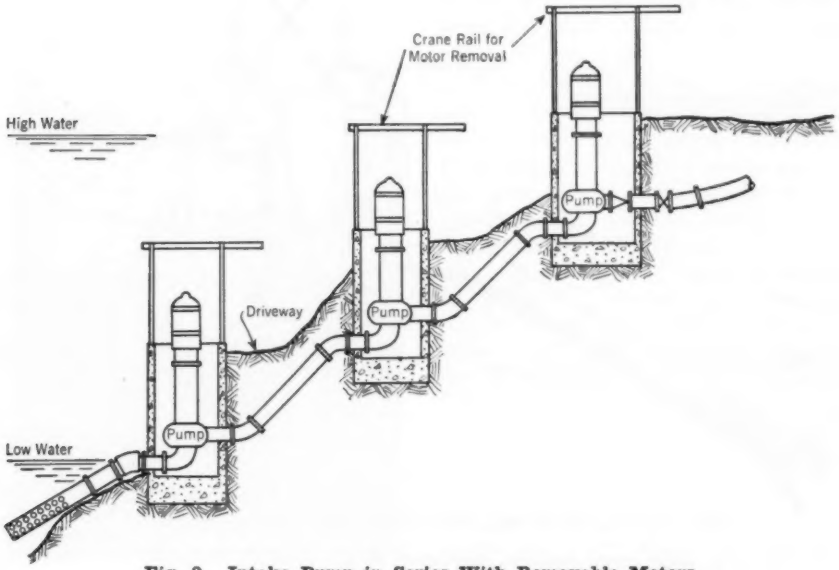


Fig. 9. Intake Pump in Series With Removable Motors

The series pumps are installed in small dry wells at elevations at least 15 to 20 ft apart.

It is not practical to anchor an intake pump barge of this type in the open channel of the Missouri River or similar stream when the river is carrying large masses of floating ice. The crushing effect of such ice cakes could be sufficiently damaging to interrupt pumping operations. Consequently, in designing a floating barge intake, anchorage in sheltered waters is desirable during some winter periods. The dike at St. Charles carrying the pipeline from the shore to the barge location provides such shelter.

A floating intake being used by the Missouri Portland Cement Co. is shown in Fig. 8. This intake is on the Missouri River at a location protected by timber dikes which maintain the navigation channel approximately 500 ft from the shore line. Shallow water exists behind the dikes and, during much of the year, sand bars are exposed making a shore intake entirely impractical. In such a location a floating intake or an intake tower was the only practical solution. Obviously, an intake tower could not be justified in place of a barge intake.

The installation shown in Fig. 8 is used for hydraulic stripping operations. Approximately 4,500 gpm of water are required. The installation

is unique in that a booster pump on the river bank is also used to produce the 175 psi operating pressure required by the hydraulic giants. The barge and booster pump are remote controlled, and an automatic priming system is used on the barge pump. Both units are horizontal, split-case, double-suction centrifugal pumps.

temporarily abandoned to the rising river. Pumping is continued through the remaining pumps in the series. There is no appreciable loss of capacity into the system upon the abandonment of a pump or pumps inasmuch as the increased river stage and consequent lower pumping head compensate for the loss of pumping stages.

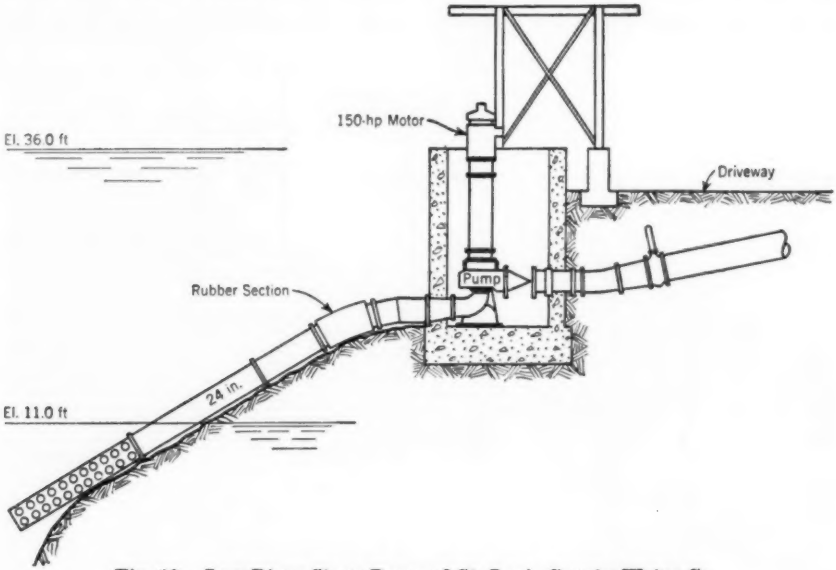


Fig. 10. Low River Stage Pump of St. Louis County Water Co.

The low river stage pump provides additional intake capacity between river stages of 14 and 36 ft.

Series Elevation Pumps

A novel intake pump arrangement which has been suggested for rivers of varying elevation is a series elevation pumping installation with removable motors. Series pumps are installed in small dry wells at elevations at least 15 to 20 ft apart (Fig. 9). When rising river elevations threaten to flood any of the pump and well units below the top unit, the motor of that unit is removed and the pump is

Low River Stage Pumps

When the total intake pumping head is relatively low, changes in river stages frequently cause important total intake capacity changes—for example, at the St. Louis County Water Co., a rise of 20 ft in river elevation will cause an almost equal drop in total pumping head (under some conditions of intake station operation), and an increase in capacity of one of the pumps from 12 to 18 mgd. Under such

conditions of changing river elevations, intake design must take into consideration the loss of pump capacity at low river stages.

One method of compensating for this loss of pumping capacity at low river stages—that is, high heads—is by the installation of a low river stage pump which becomes a standby pump or even inoperative at high river stages. A low river stage pump design



Fig. 11. Low River Stage Pump of St. Louis County Water Co.

at the St. Louis County Water Co. is illustrated in Fig. 10 and 11.

The St. Louis County Water Co. low river stage pump provides additional intake capacity between river stages of 14 and 36 ft. The center line of the pump is at elevation 26. When the river stage approaches 36 ft, the vertical pump motor is removed and the pump is temporarily abandoned to the rising river. A study of a stage-duration curve for the Missouri River shows that this pump can be operated 85 to 90 per cent of the time.

Wells in River Alluvium

The river alluvium well and similar infiltration devices are useful in river bottom areas subject to frequent flooding. These installations take water from ground water sources adjacent to the river channel rather than directly from the river. Although the river alluvium well is not, strictly speaking, a river type intake, the water available in the well frequently constitutes an adequate water supply because of its nearness to the river and is generally a more economical source if requirements are small. Ground water tables are usually appreciably influenced by the river water elevation. In addition, although the chemical characteristics of the ground water are not as a rule identical with the water in the adjacent river, there is frequently a definite, recognizable similarity. The river alluvium well and river intakes are considered together because the designing engineer must weight the advantages and disadvantages of one against the other when developing a new or added water supply.

The river alluvium well, if cased sufficiently high, is not affected by floods, moving river channel, ice, and many of the other problems common to the true river intakes. Water temperatures and water characteristics are more uniform than in the adjacent river. To determine whether the river alluvium well is economically sound requires an engineering study of such factors as water treatment and softening, well maintenance, well yield, well life, and size of the well field required.

The wells in the alluvial flats of the Missouri River bottom at the Weldon Springs, Mo., Ordnance Plant are an interesting example of a water supply developed in a river bottom. Thirteen 38-in. diameter gravel-wall wells averaging 100 ft deep to bedrock, drilled approximately 1,200 ft apart, delivered up to approximately 3½ mgd each. Four of the wells are approximately 400 ft from the normal river edge. The most distant well is approximately 4,200 ft from the river.



Fig. 12. Ranney Collector at Kirkwood, Mo.

The installation is built on the banks of the Meramec River which is subject to frequent flash floods.

During the period when the ordnance plant was in operation, it was observed that the water table in the wells nearest the river varied in almost direct proportion to the water level in the river. The water table level changes in the more distant wells also corresponded to changes in level in the river but after a greater time delay.

Initially the chemical characteristics of the water from all of the wells were entirely unlike those in the river water. The well water was very hard, high in iron and carbon dioxide. After two years of pumping, however, the water in the wells nearest the river had characteristics which were similar in a number of respects to those of the river water. In addition, the water in all of the wells was continually changing, with a steady decrease in mineral and gas content. It was the belief of the operators that if the wells had remained in continuous service, the ground water would eventually have assumed the general characteristics of the river water.

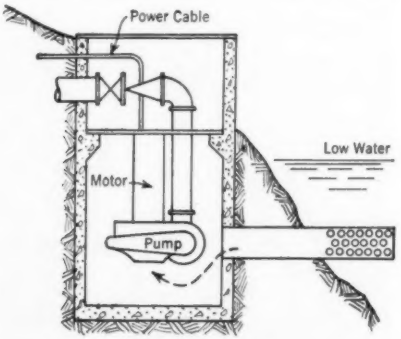


Fig. 13. Submersible Intake Pump in Well

As pump and motor can be completely submerged, construction need not be carried to elevations above high water.

The tops of the well casings were above maximum floodwater level; consequently, the delivery from the wells was not hampered by changing river conditions, such as floods, low water, ice, or shifting banks. The cost of the installation is believed to have been considerably less than that for other types of river intakes suitable for this location and of comparable size.

The Ranney collector (Fig. 12) at Kirkwood, Mo., built on the banks of the Meramec River, is another ex-

ample of a river bottom well which was selected as a means of coping with a variable stream. The Meramec River is subject to frequent flash floods following heavy rains, and to extreme low water levels during periods of drought. The frequently changing flow in the river also results in extreme variations in water characteristics, some of which occur within a few hours. The variable river conditions—as well as floating debris during floods, floating leaves and algae during low water, and ice during winter—resulted in the abandonment of a pipe strainer intake extending into the river at Kirkwood. In its place, a Ranney collector was built approximately 75 ft from the normal water's edge. This collector consists of a circular reinforced concrete caisson 13 ft in diameter and 85 ft deep. The bottom is sealed off with concrete which is placed by a tremie, an apparatus for depositing and consolidating concrete under water. The top is above extreme high water elevation and even though floodwater completely surrounds the well, operation is not adversely affected. Eleven radial, perforated collector pipes 6 in. in diameter extend an average of 100 ft into porous strata and serve as ducts to drain the ground water into the caisson.

An average of 1.5 to 2.0 mgd of water is pumped from this collector. It is estimated to have the capacity for delivering several times the present daily requirement without presenting any of the difficulties experienced with the old river intake.

Submersible Pump Intakes

The submersible pump and intake has been successfully applied on streams and rivers which flood. Simple shore type intake structures are constructed and submersible pumps are installed during low water. Inasmuch as pump and motor can be completely submerged, construction need not be carried to elevations above high water. Intakes of this type (Fig. 13) are reported to have been constructed at Grand Forks, and at Drayton, N.D. Another similar type is shown in Fig. 14.

Small submersible pumps and motors can be installed in almost any position —vertical, horizontal, or upon an incline. When river bank conditions permit, inclined submersible pumps (Fig. 15) have many desirable features. The pumps can be installed with a minimum amount of bank improvement and without underwater construction by sliding the units down an inclined skid during low water periods.

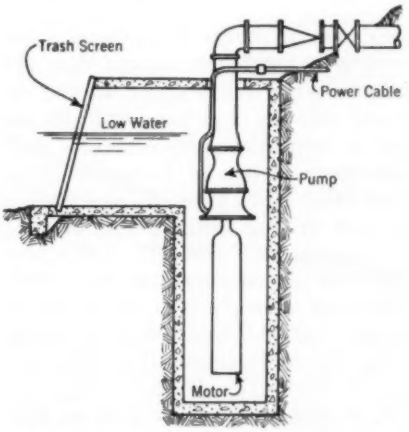


Fig. 14. Submersible Intake Pump in Well
The submersible pumps are installed during low water.

Siphon Well Intakes

The siphon well intake is a fixed shore type of wet pit intake which receives its water from the river through a siphon line. The siphon intake well

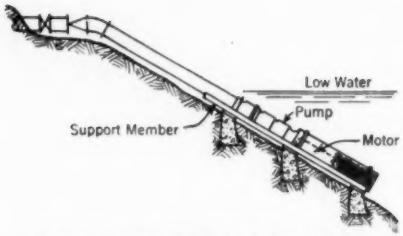


Fig. 15. Submersible Intake Pump on Incline

Inclined submersible pumps can be installed with a minimum amount of bank improvement and without underwater construction.

may even be similar to a ground water well in construction, except that the bottom of the well is sealed off and the water entering and pumped from the well is from surface sources. Its chief advantage is one of lower first cost than other types of fixed shore intakes as well drilling methods can be used to construct the wet pit. Little construction is required under water. This type of intake is in use at the St. Louis County Water Co. in St. Louis (Fig. 16), at Eddington, Pa. (Fig. 17), and at Rotterdam, Holland (Fig. 18). These intakes take water from the Missouri, Delaware, and Maas Rivers, respectively.

One of the siphon intake wells at the St. Louis County Water Co. installation consists of a 50-in. diameter steel well casing placed approximately 50 ft from the normal edge of the river. The top of the well casing is a few feet above maximum high water. The well is 54 ft deep and is sealed at the bottom with a plug of tremie concrete. The deepest part of the well is approximately 18 ft below minimum low water. River water enters the well through a 24-in. pipeline connecting the well with the river which is the influent side of the siphon. The river water is carried to the bottom of the well through the annular space formed by another casing tube, 33 in. in diameter, which is hung within the well. This annular space between the inner and outer well casings, which is sealed to atmosphere at the top, is the effluent leg of the siphon. The siphon is primed by producing a vacuum between the inner and outer casings.

The siphon pipeline is laid a few feet above low river water elevation until it reaches the river's edge. At the river's edge the pipeline is dropped into the river water through a flexible pipeline connection. The entire pipeline was constructed above water during low water periods and resulted in important savings in the cost of construction.

A 30-in. mixed-flow, well type vertical pump, powered by a vertical out-

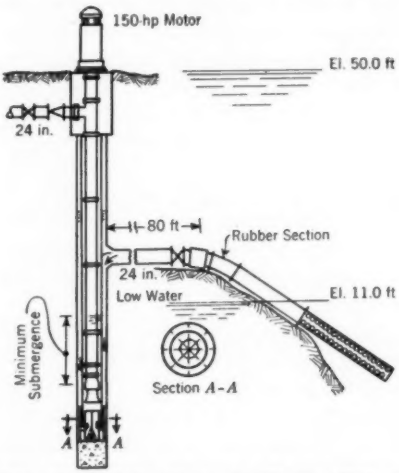


Fig. 16. Intake Pump in Siphon Well of St. Louis County Water Co.

The siphon well intake is a fixed shore type of wet pit intake which receives its water from the river through a siphon line. The water level between casings varies with vacuum drawn to prime siphon.

of-door hollow shaft, 150-hp electric motor is installed within the well. This intake installation is entirely out-of-doors and has functioned satisfactorily in both winter and summer after certain hydraulic design deficiencies were corrected.

Axial and mixed-flow pumps, because of their high specific speed, are especially sensitive to flow irregularities which occur on the suction side of the pump even when there is sufficient

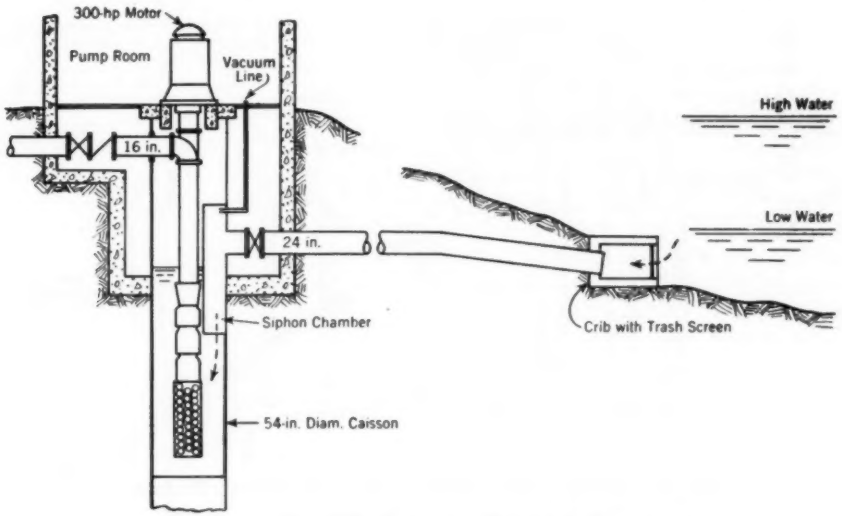


Fig. 17. Intake Pump in Siphon Well in Eddington, Pa.

Water is taken from the Delaware River.

submergence. The flow into the pump must be uniformly distributed so that no portion of the impeller's inlet area is starved for water. Uneven flow distribution will cause cavitation, vibration, excessive thrust on the shaft and bearings, and resulting mechanical troubles. In addition, the water entering the pump must not be in a state of prerotation. When the water is in a whirling motion about the pump's axis, there may be an important loss of capacity or increased horsepower requirements.

These difficulties were encountered in one of the siphon intake wells at the St. Louis County Water Co. soon after pumping operations were begun. Model tests of the installation made by the pump manufacturer indicated prerotation and uneven flow into the pump. When the pump was taken out of service after a few months of operation, the impeller and bowl showed severe cavitation and the lower bearings and shaft sleeves were completely worn out. These difficulties were corrected by deepening the well so that there was longer straight pipe flow after the water made its 180-deg turn and by installing straightening vanes.

The siphon well intake is unaffected by flood or low water conditions on the river. It is also unaffected by river icing. In addition, a very important consideration is the ease by which it

can be adapted to remote-control operation.

Suspended Types

The outstanding developments which have been made in vertical well type, mixed- and axial-flow pumps make possible the construction of intakes in which pumping units can be suspended into the stream. The suspending structure may be a bridge or a special high-level platform founded on piling.

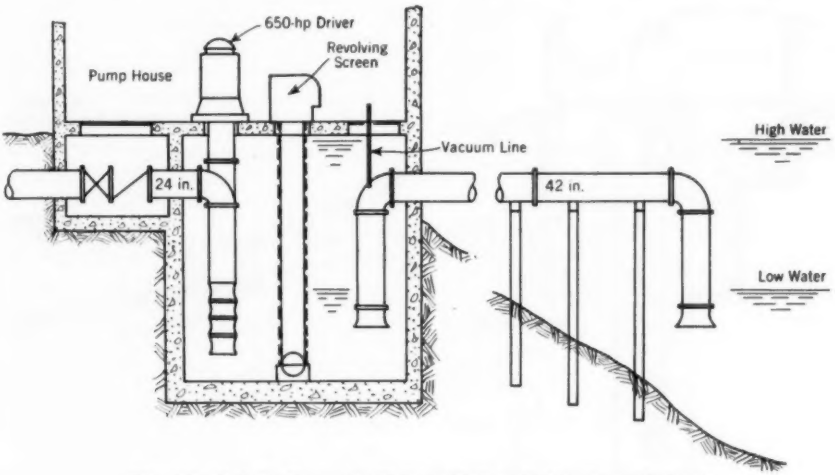


Fig. 18. Intake Pump in Siphon Well in Rotterdam, Holland

Water is taken from the Maas River.

Figure 19 shows an intake of the Missouri Portland Cement Co. Plant at St. Louis on the Mississippi River. The three-stage well type pumps are suspended from a pier on the barge loading dock. The motors are well above high water. The pump columns are protected by a steel casing comparable to a well casing.

The advantage of this type of intake lies in its low cost and the elimination of costly underwater construction. The pump must be protected from drift and navigation and for this purpose it may be necessary to construct an outer protecting fender of piling. One of the principal disadvantages results from the exposure of the pipe and pump column, thus making it difficult to operate in cold climates. The use of electric heating to prevent freezing is practical. The St. Louis County Water Co. intake pipes are wrapped with hot bed-type heating wires and are insulated. A wattage density of 20 per sq ft is adequate. Thus 9 ft of 24-in. pipe can be protected with an input of 1 kw. Operating costs are not important because of the short period of subfreezing temperatures. In the St. Louis area, for example, there are only 314 degree-days a year below freezing. Actually heating would scarcely be required unless the air temperature is less than 25 F.

Intake Pumps

The many problems of intakes on variable streams have created demands

for pumping units of special construction and design. Certain types of intakes are predicated on the use of certain types of pumps. In others, the choice of pumping unit is optional and must be based on other considerations. Insofar as the pump itself is concerned

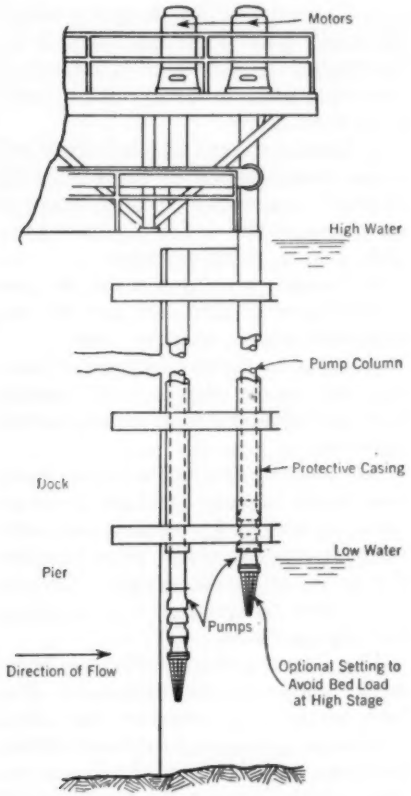


Fig. 19. Suspended Intake of the Missouri Portland Cement Co. Plant

The three-stage well type pumps are suspended from a pier on the barge loading dock.

from the standpoint of reliability, maintenance, operation, and first cost, no pump is better adapted to the many problems of intakes on variable streams than the horizontal, split-case, double-suction, volute type centrifugal pump of low specific speed. When an intake design requires the use of other types, such as vertical wet and dry well units, a saving in initial cost must offset the advantages of the horizontal pump.

The advantages of the wet well types of pumps in eliminating uplift and flotation problems are offset by the higher first cost of both pump and motor and the difficulties of maintenance. The vertical types commonly used have axial or mixed flow impellers which have high specific speeds. The high speed aggravates abrasion problems and the need for greater submergence because of cavitation considerations, but permits the use of a less costly motor. This advantage is generally offset by the inherently higher cost of vertical motors, however. Abrasion and cavitation difficulties can be minimized by the use of special materials in impeller and bowl construction. Some success has been reported in minimizing abrasion problems by using stainless steel applied by metallizing.

One of the important advantages of the vertical type is that the motor can be placed as high as desired, thus completely eliminating the problem of flooding of motors and equipment as a result of pipeline failures in dry wells. This factor may be very important if only one intake is available for a municipal supply.

Conclusions

Variability of a stream manifests itself in wide variation in water levels, shallow depth at low stage, instability of bottom and shore line, flood hazard, heavy bed loads, excessive drift and floating material, and, in cold climates, difficulties resulting from floating ice. All or some of these manifestations may

be present in every intake situation on variable streams. A successful installation gives proper consideration in its design, maintenance, and operation to all the difficulties that may arise. Experience has shown that the following conclusions can be justified.

1. Intake problems on variable streams cannot always be solved by ponderous structures because: [a] a small community or installation cannot afford massive structures or major channel maintenance work; [b] the annual cost of an installation consisting of massive structures and needed channel improvements probably will be greater than that for other satisfactory installations of less first cost; or [c] a massive intake installation is not always flexible or amenable to ready solution of emergency problems which were unforeseeable when it was designed.

2. Intakes consisting of pumps on barges and on inclined tracks have been and can be designed to give reliable, low-cost service. These types often offer the best solution to the difficulties of exceptional low water and flood. They offer welcome relief from bed load problems which may cause serious pump maintenance difficulties in massive fixed intakes.

3. Careful selection of site may solve many of the problems of variable streams.

4. Screening should be held to a minimum and should be determined only by the possibility of damage to pumps and by possible difficulty in the purification plant. In general, difficulty in the purification plant is a minor consideration, and the ability of the pumps to pass solids should be the determining factor.

5. In establishing the flood height for which the intake is designed, a considerable margin above record information should be added. Experience has shown that such a conservative approach is the only safe course.

6. The extreme low level for which the intake must be designed should be determined by the same conservative approach used in establishing maximum flood height.

7. Maximum operating efficiency requires consideration of the variability of head. A duration curve of stages is necessary in the design to make possible proper pump selection.

8. Intake structures must be designed to resist drift, ice, and the inadvertent impact of river craft.

9. Riparian rights may have a bearing on intake design. A permit may be necessary from governmental agencies.

10. The improvements which have been made in pumps and the development of wet well, vertical, and submersible types in recent years broaden the scope of intake design. Certain types offer natural low cost solutions to some problems.

11. Gravel-packed wells or horizontal collector type infiltration systems in the river alluvium may offer economical solutions to difficult intake problems, provided purification problems which increase the total overall annual cost are not created.

12. Careful consideration must be given in design and pump selection to cavitation, abrasion, and pump construction.

Developments in Tests of Coatings for Steel Pipe

By Graydon E. Burnett and Charles B. Masin

A paper presented on May 7, 1952, at the Annual Conference, Kansas City, Mo., by Graydon E. Burnett and Charles B. Masin, Engrs., Design and Construction Div., U.S. Bureau of Reclamation, Denver, Colo.

SUBSTANTIAL improvements have been made in recent years in coating protection for steel pipe. If the proper materials are used and care is taken in their application, there is reasonable assurance that steel water pipe will have long life in most conditions of use. This does not mean, however, that there is no room for further progress. First, it is always possible that as good or better results might be obtained at less cost, and, second, improvements are still needed in coatings for steel pipe in certain exposures. For these reasons, the U.S. Bureau of Reclamation is continuing a program of protective-coating investigations in the laboratory and in the field.

This paper discusses some of the more recent developments in bureau tests of coatings for steel pipe. It is hoped that the data will be helpful in the discovery of complete and economical protection for steel pipe under all conditions of use.

Shasta Dam Penstock Tests

Before the Shasta Dam tests were started, the bureau had determined, from 6-year tests starting in 1940 in outlet pipes of Grand Coulee Dam, that coal-tar enamel, CA-50 coal-tar paint, and a vinyl-resin paint provided durable linings for steel water pipe. Of these materials, coal-tar enamel had the longest service background and accordingly it has since been used most extensively by the bureau.

During and immediately after World War II, numerous new coating materials appeared, several of which looked promising in laboratory tests, for the protection of steel pipe. Consequently, it was decided to include these coatings and certain others recommended by manufacturers in a new service test in one of the 15-ft diameter penstocks of Shasta Dam. The prime purpose was to evaluate the serviceability of the new products in penstocks, but the data are also applicable to other steel water pipe and to submerged steel in general.

In June 1949 twenty different coatings were applied in 26 different systems to 160 lin ft of the interior of Penstock 5 of Shasta Dam. Most of the materials were furnished by participating manufacturers and were either applied by company representatives or else the application was witnessed by them. Cold-applied coatings included paints with phenolic, vinyl, vinyl-thiokol, vinylidene-acrylonitrile, treated fish oil, synthetic rubber, and coal-tar bases. Among the hot applications were catalytically blown asphalt applied by hand daubing and microcrystalline wax applied by liquid spray.

TABLE 1—*Ratings of Test Linings in Shasta Dam Penstock as of October 1951*

Type of Coating*	Coats						Average Dry-Film Thickness *mils*	Remarks
	1st	2nd	3rd	4th	5th	6th		
Class A—Coatings Showing No Rust Spots or Film Defects								
Cold-applied phenolic paint	Prime	Prime	Finish	Finish			4	
Cold-applied phenolic paint	Finish	Finish	Finish	Finish			5	
[Red-lead phenolic paint]†	Finish	Finish	Finish	Finish	Finish		8	
[Red-lead phenolic paint	Wash prime	Finish	Finish	Finish	Finish	Finish	8	
Red-lead phenolic paint]	Special oil	Finish	Finish	Finish	Finish	Finish	8	
[Red-lead phenolic paint]†	Finish	Finish	Finish	Finish			5	
[Red-lead phenolic paint	Wash prime	Finish	Finish	Finish	Finish		5	
Red-lead phenolic paint]	Special oil	Finish	Finish	Finish	Finish		5	
Coal-tar paint (CA-50)	Finish	Finish	Finish	Finish	Finish		20	
Vinyl-resin paint	Prime	Body No. 1	Body No. 1	Body No. 2	Seal	Seal	10	
Vinyl-resin paint	Finish No. 1	Finish No. 1	Finish No. 2	Finish No. 2			4.2	
Flame-sprayed thiokol‡							31	
Class B—Coatings Showing Not More Than a Few Rust Spots								
Catalytically blown asphalt (melt)§							90	Severe surface checking. Rust at pinholes
Vinyl-thiokol paint ‖#	Prime	Prime					18	Rust spots. Invert only
Flame-sprayed phenolic plastic**	Prime						32	Surface checks. Film degradation
Cold-applied synthetic rubber paint	Prime	Finish	Finish	Finish			9	Pinhead blistering. Rust spots on invert
Vinyl-thiokol paint	Prime	Finish	Finish	Finish			7	Very few rust spots. Invert only
Class C—Coatings Showing Numerous Rust Spots								
Coal-tar emulsion	Finish	Finish					7	Pinhole rusting on invert and arch
Microcrystalline wax (hot spray)‡††							33	Rust spotting. Fine surface checks
Microcrystalline wax (hot spray)**††	Prime						33	Rust spotting. Fine surface checks
Vinyl-resin paint	Finish	Finish	Finish				3.5	General rust spotting
Zinc chromate–fish oil paint	Prime	Finish					2.5	Rust spots and blistering
Vinyl-thiokol paint ‖	Prime	Prime	Finish	Finish	Finish		8	Rust spots in arch and invert
Class D—Coatings Permitting Rusting on More Than 25 Per Cent of Area (Failure)								
Flame-sprayed zinc wire‡							11	Large rusted areas. Rust tubercules
Flame-sprayed zinc powder‡							1.7	85% deterioration as of October 1949
Vinylidene-acrylonitrile emulsion	Finish	Finish	Finish				10	General rusting as of October 1949

* Coatings are not listed in order of preference within classes.
† Each group set off by brackets had the same coating but different surface treatments.
‡ One coat built up by multiple passes.
§ One coat built up by shingling with hand daubers
‖ Same coating applied in medium and thick films.
Nine finish coats.
** Finish coat built up by multiple passes.
†† Same coating applied over primed and unprimed steel.

A phenolic plastic, thiokol, and zinc metal were applied by flame spray. Coal-tar enamel was applied by hand daubing to the penstock exclusive of the test area.

Great care was taken to see that applications were made properly. The steel surfaces were thoroughly sand-blasted to remove all rust and mill scale. Coatings not actually applied by manufacturers' representatives were applied in strict accordance with the manufacturers' instructions. In the few tests for which instructions were lacking, the coatings were applied in accordance with the best judgment of bureau engineers.

The last inspection of the coatings was made in October 1951, after the penstock had been in nearly continuous service for 2 years and 4 months. Although this period is not long for a test of this type, significant results were already apparent. As indicated in Table 1, eight of the twenty coatings showed no rust spots or film defects and were classified as Class A coatings. Five showed only a few rust spots and were placed in Class B. Four showing numerous rust spots were placed in Class C, and three coatings permitting extensive rusting were classified as D.

Phenolic and vinyl-resin paints are predominant in Class A. One vinyl paint is in Class C, but it is felt that this paint was applied too thinly for the type of pigmentation used. The current high regard of many coating engineers for phenolic and vinyl paints in underwater service therefore seems to be verified. Flame-sprayed thiokol also is in Class A. As yet there is no evidence that these coatings will prove superior to coal-tar enamel, which is in excellent condition in the remainder of the penstock—for example, CA–50 coal-tar paint, which is known to be less durable than coal-tar enamel, is still in Class A in these tests. Nevertheless, these coatings look very good and some may be better suited than coal-tar enamel as a lining for steel pipe in certain exposures, especially extreme cold.

In the vinyl-thiokol group, one coating, although placed in Class B because of a few rust spots in the invert, is practically in Class A. Another vinyl-thiokol coating was applied in both medium and thick films. The medium coating falls in Class C, whereas the thicker film is in Class B, thus emphasizing the importance of obtaining adequate film thickness.

The catalytically blown asphalt, Class B, was in very good condition in October 1950, at which time it exhibited only a superficial surface checking. At the October 1951 inspection, the surface checking was severe, although the coating was still very plastic. Pinhole rusting has developed where holidays in the coating were not patched. This condition is not considered a defect, however, because material of this type normally is holiday detected and patched.

The flame-sprayed phenolic plastic, Class B, is beginning to show definite signs of film degradation. The coating is blotchy, and widely spaced surface checks are evident. The cold-applied self-curing rubber coating, also Class B, has developed pinhead blistering in some areas, and there are a few rust spots in the invert. In October 1950 this coating was in Class A but showed indications of poor adhesion that might affect its ultimate durability. An identification card was secured to each coating with scotch tape before photographing. In pulling the card away, the tape lifted the rubber coating.

TABLE 2—*Performance of Linings in Shadow Mountain Low-Temperature Tests*

Type of Coating*	Coats			
	1st	2nd	3rd	4th
Coal-tar paint (CA–50)	Finish	Finish	Finish	
Cold-applied asphalt paint	Finish	Finish	Finish	
Vinyl-resin paint†	Prime	Body No. 1	Body No. 2	Body No. 1
Vinyl-resin paint†	Wash prime	Prime	Body No. 1	Body No. 2
Neoprene paint‡	Prime	Prime	Body	Body
Neoprene paint‡§	Prime	Prime		
Vinyl-thiokol paint	Prime	Prime	Finish	Finish
Vinyl-thiokol paint	Finish	Finish	Finish	Finish
Wax-cellulose paint‖	Prime	Finish	Finish	
Wax-cellulose paint‖	Finish	Finish		
Zinc in inorganic vehicle (flamed)#	Finish	Finish		
Zinc in inorganic vehicle (flamed)#	Finish			
Microcrystalline wax‖	Finish	Finish		
Microcrystalline wax‖	Prime	Finish	Finish	
Cement mortar**				
Preshrunk cement mortar**				
Coal-tar enamel, 1½ penetration††	Prime			
Coal-tar enamel, 2 penetration††	Prime			
Coal-tar enamel, 3 penetration††	Prime			
Coal-tar enamel, 4 penetration††	Prime			
Coal-tar enamel, 5 penetration††	Prime			
Coal-tar enamel, 6 penetration††	Prime			
Coal-tar enamel, 7 penetration††	Prime			
Coal-tar enamel, 9 penetration††	Prime			
Coal-tar enamel, 10 penetration††	Prime			

* Coatings are not listed in order of preference.
† Same coating over different surface treatments.
‡ Same coating applied in medium and thick films.
§ Twelve body coats.

Of the Class C coatings not discussed thus far, the coal-tar emulsion shows pinhole rusting in both arch and invert; the microcrystalline wax is starting to check and is rust spotted at and below the spring line; and the zinc chromate–fish oil coating is rust spotted and blistered, especially in the invert. The wax, although inherently a very moistureproof material, was difficult to apply in a uniform film. The coal-tar emulsion might have special application for surfaces that cannot be thoroughly dried for painting with more effective materials. The zinc chromate–fish oil system was applied after the sandblasted surface had been permitted to rust slightly at the request of the manufacturer. It was the thinnest of all organic coatings applied in this test and would likely have fared better if the manufacturer had recommended application in a thicker film.

In the Class D coatings, the vinylidene-acrylonitrile emulsion failed in 4 months. The sprayed zinc powder also failed in 4 months, but this failure is believed to have resulted from inadequate thickness. The failure of the zinc-wire metallized coating is difficult

TABLE 2 (*contd.*)—*Performance of Linings in Shadow Mountain Low-Temperature Tests*

Coats (*contd.*)			Average Dry-Film Thickness *mils*	Submerged Exposure *months*	Atmospheric Exposure *months*	Remarks
5th	6th	7th				
			15	7	13	No defects. Exposed to −41 F
			34	7	13	No defects. Exposed to −41 F
Seal	Seal		12.5	3	8	No defects. Exposed to −41 F
Body No. 1	Seal	Seal	12.5	3	8	No defects. Exposed to −41 F
Body	Body	Body	18	3	8	No defects. Exposed to −41 F
			40	3	8	No defects. Exposed to −41 F
			7	3	0	No defects
			6	3	0	No defects
			17	3	8	No defects. Exposed to −41 F
			8	7	13	Rust spotting. Exposed to −41 F
			3	3	0	No defects
			1.5	3	0	Rust spot 1 sq ft in area
			120	3	8	Cracking and disbonding at −41 F
			87	3	8	Cracking and disbonding at −25 F
			300	4	10	Shrinkage, cracking, and disbonding
			300	3	0	Several hairline cracks. Coating bonded
			128	0	5	General cracking, 72% disbonded at −41 F
			130	0	5	General cracking, 38% disbonded at −41 F
			110	0	5	General cracking, 32% disbonded at −41 F
			110	0	5	General cracking, 18% disbonded at −41 F
			70	3	8	General cracking, 1% disbonded at −41 F
			97	3	8	Hairline cracking, 0% disbonded at −41 F
			93	3	8	Hairline cracking in arch only at −41 F
			80	3	8	No defects. Exposed to −41 F
			78	3	8	No defects. Exposed to −41 F

|| Same coating applied over primed and unprimed steel.
Same coating applied in one and two coats.
** One coat built up with trowel.
†† Finish coat built up by shingling with hand daubers.

to understand. The worst rusting occurred in the thinner portions of the coating, yet even the minimum thickness in the range from 7 to 15 mils, as applied, should have been adequate for this length of service.

Low-Temperature Tests

The provision of durable protection against corrosion of the interior of water-bearing steel pipe that is empty and exposed to subzero temperatures during the winter months is a difficult and ever-present problem of the Bureau of Reclamation.

Coal-tar enamel on the interior of 87-in. diameter discharge pipe sections at Granby Pumping Plant, Colo., cracked and disbonded when subjected to temperatures ranging down to − 38 F. A cement-mortar lining in the exposed Shoshone River Siphon, near Cody, Wyo., was in distressed condition after service through one winter with temperatures as low as − 31 F. Microcrystalline wax on the interior of a 30-in. diameter, steel pipe flume near Lyman, Neb., cracked and disbonded in near-zero temperatures, even though laboratory tests indicated that it would

stay bonded to steel at the extreme low temperatures encountered in northern projects.

After the poor correlation of laboratory tests with the field application of microcrystalline wax, it was decided that the answers to finding suitable protection for the interior of steel pipe exposed to low temperatures would come only from tests conducted under field conditions.

hand-daubed coal-tar enamel having penetrations 1½ through 10 (ASTM D–5) as applied, and microcrystalline wax. The two cement-mortar linings were also applied by hand.

The lined pipe sections were transported to Shadow Mountain Reservoir, more than 8,000 ft above sea level, near Grand Lake, Colo. Here the sections are set out horizontally, supported off the ground on skids, and exposed to



Fig. 1. Low-Penetration, Coal-Tar Enamel Pipe Lining Before Exposure

Penetration values of 1½, 2, 3, and 4 are shown.

Starting in February 1950, various linings were applied in Denver to the interior of 30-in. diameter, steel pipe sections. The surfaces were prepared by thorough sandblasting to base metal, except that cement mortar was applied to power wire-brushed surfaces. Among the cold-applied materials were paints with coal-tar, asphalt, wax-cellulose, vinyl, vinyl-thiokol, and neoprene bases, and zinc powder in an inorganic vehicle. The hot-applied linings were

low atmospheric temperatures during the winter. The ends of each section are covered with canvas to prevent undue air movement and contamination. During the warmer months of the year, the sections are submerged in the inlet canal to Shadow Mountain Reservoir. Thus, both low-temperature susceptibility and corrosion-preventive data are being obtained. Most of the linings were subjected to temperatures down to − 41 F during the winter of

1950–51. Some linings were not applied until the summer of 1951.

Detailed information on the Shadow Mountain tests is given in Table 2. The coatings are listed by general types, and each system is identified as to number and type of coats and final dry-film thickness. In addition, the total time of submerged exposure and total time of atmospheric exposure up to October 1951 are given for each system.

Coal-tar paint (CA–50), asphalt paint, vinyl-resin paint with and without a wash prime, neoprene, and the wax-cellulose paint were unaffected by temperatures as low as − 41 F. The vinyl-thiokol paints and the zinc in inorganic vehicle had not yet been exposed to winter temperatures. The importance of obtaining adequate film thickness is again demonstrated. The 8-mil coating of the wax-cellulose paint has permitted rust spotting, and the 17-mil coating has not. Similarly, the 1.5-mil zinc–inorganic vehicle coating has permitted rusting, and the 3-mil coating has not. It is also apparent that critical thickness varies with different types of coatings.

The microcrystalline-wax lining became generally disbonded when applied either directly to metal or over a prime coat. The first cement-mortar lining deteriorated from drying shrinkage; however, a preshrunk, air-entrained mortar applied later is still in excellent condition. A regular improvement in performance of coal-tar enamel, when subjected to a temperature of − 41 F, occurred with increase in plasticity as measured by the penetration test. Thus, 1½-penetration material was 72 per cent disbonded; 5-penetration enamel was only 1 per cent disbonded; and 9- and 10-penetration material was completely unaffected. Figures 1 and 2 show the condition of the low-penetration coal-tar enamel as applied and after exposure to a temperature of − 41 F. Penetration values are painted on the enamel. Disbonded and cracked areas are visible in the arch of pipe, and enamel in areas of lowest penetration has fallen completely away from the pipe and is lying in the invert.

These results on coal-tar enamel support the Bureau of Reclamation specifications requirement for a minimum penetration of 7, as applied to the pipe, when the enamel will be exposed to cold. By starting with 15–20-penetration material (provided for in specifications AWWA C–203 and C–204 for enamel exposed to temperatures between 20 and − 20 F), and by properly controlling the heating operation, an average penetration of approximately 10 is obtained from a batch. Only the last bucket or two of enamel withdrawn from the heating kettle approaches 7 penetration. Even this minimum-penetration enamel is expected to perform satisfactorily at a low of − 20 F.

Various exterior coatings are also under test on these pipe sections, but no significant results are apparent as yet. The tests will be continued to determine the effect of repeated cycles of low-temperature and submerged exposures on both the linings and coatings.

Buried-Pipe Tests

Laboratory tests are being conducted to provide information on the behavior of various exterior pipe coatings and wraps in clay soil subject to alternate wetting and drying, and on their relative resistance to puncture by rocks in backfill.

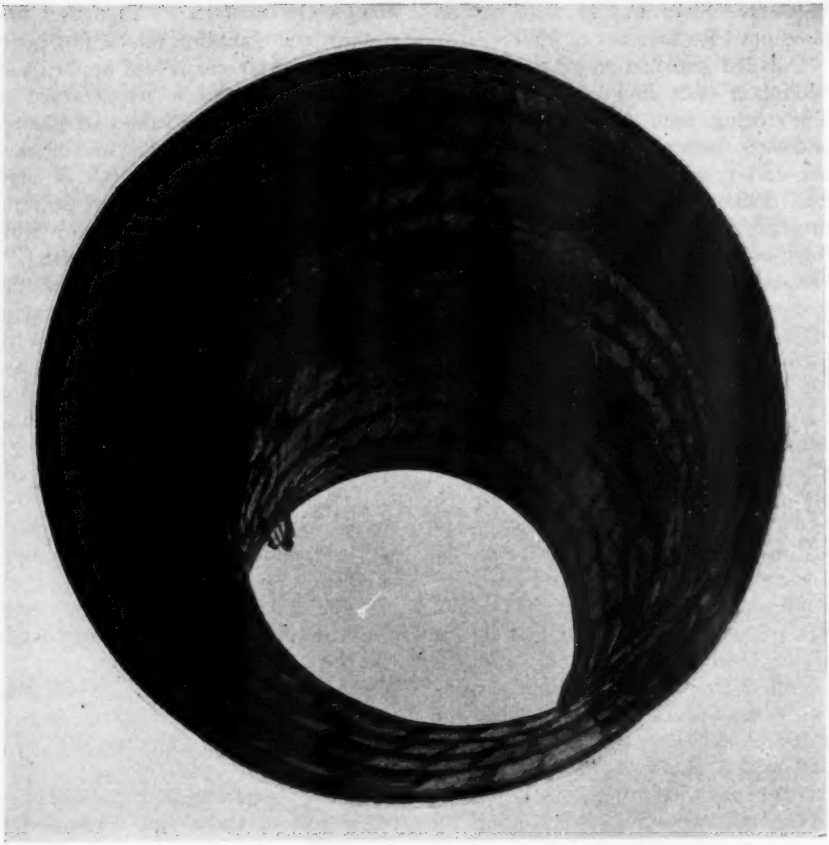


Fig. 2. Low-Penetration, Coal-Tar Enamel Pipe Lining After Exposure

The pipe was exposed to a temperature of −41 F. The low penetration values, 1½ and 2, are shown on the end of the pipe nearest the camera. Enamel in this low-penetration area has fallen completely away from the pipe. The higher values, 3, 4, and 5, are shown at the other end of the pipe.

The coatings have been placed on sections of steel pipe of 3½-in. OD and 18 in. long. There are twelve specimens of machine-applied coal-tar enamel coatings with various combinations of inner reinforcing and outer wraps or treatments. On some specimens the enamel, as applied, had a penetration of 4, while on others the penetration was 7 or 8. Other specimens have coatings of asphaltic enamel with and without felt wrapping, cold-applied coal-tar paint, cement mortar, and cold- and hot-applied tape wraps. Two specimens have coatings of plasticized gilsonite, differing in inner reinforcement but having the same outer wrapper are included. There is also in-

cluded one wrapped microcrystalline-wax specimen.

Soil Test

The soil test is being carried out in a wooden box, 1 × 3 × 9½ ft, lined with galvanized sheeting. A bank of infrared lamps is placed above the box to accelerate drying of the clay by uniform heating of the surface. A 2-in. layer of gravel is in the bottom of the box and over this is a 2-in. layer of clay. The test specimens are placed on this clay mat and their tops are covered to a depth of 2 in. with clay slurry. This slurry is prepared by crushing the clay in a 6 × 6-in. jaw crusher and mixing with water in an agitator-equipped tank. After the slurry has set for 2 days, the infrared lamps are turned on for a 12-day period. During this 2-week drying period, air is circulated over the surface of the clay by an electric fan. The surface temperature of the clay ranges from 83 to 112 F during this time. The temperature at the top of the pipe ranges from 82 to 107 F and at the bottom of the pipe from 77 to 94 F. Tight-fitting wooden plugs were driven into the pipe ends and the ends were then sealed with coal-tar enamel, CA–50 coal-tar paint, or microcrystalline wax, depending on the type of coating.

The clay, thoroughly dry and extensively cracked after the 2-week drying period, is broken up by light tapping with a hammer and then lifted away in segments from the test specimens, which are cleaned for examination by soaking in water and scrubbing with a brush. Figures 3 and 4 show the pipe arrangement in the soil box and the appearance of the clay at the end of the drying cycle.

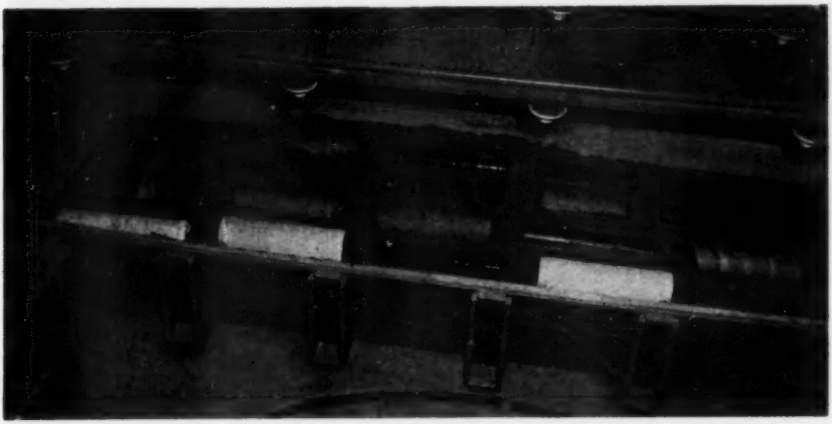


Fig. 3. Specimen Arrangement in Clay Soil Box

The clay is of the type commonly known as "lean" and is not considered to have exceptionally severe expansion or contraction characteristics. It has a liquid limit of 40.4, plasticity index of 21.1, and a shrinkage limit of 14.6. Its corrosion index (Corfield test) is 1.99, which is in the moderate range of corrosivity.

Indentation Test

The test used to evaluate the resistance of coatings to puncturing by rocks in backfill is called an "indentation" test. In this test the coatings are subjected to a load of 6.48 lb bearing on 0.049 sq in., the cross-sectional area of the rod. This load corresponds to a pressure of 132 psi. The total load is equivalent to the weight of a rock approximately 5 in. in diameter. The indentation test apparatus is shown in Fig. 5.

Depending upon the shape of the rock and how well the backfill has been placed, the contact pressure may be considerably higher than the average backfill pressure. It is conceivable that this test condition could be duplicated in the field by a 2- or 3-in. rock bearing directly on the coated pipe surface. Therefore, although this test actually demonstrates the relative resistance to indentation of various coatings under fixed loading conditions, it is believed that the results are indicative of what could happen under field conditions. The indentation tests were made on specimens prepared similarly to those used in the soil stress tests. The tests were conducted in an atmosphere controlled to 73.5 F and 50 per cent relative humidity. The extent of penetration was read daily from a scale on the rod until no additional change was apparent for several days. The indented area was then electrically detected to determine whether or not damaging perforation of the coating had occurred.

Table 3 describes the coating systems by general types and gives coating thicknesses and results of the 10,000-v electrical flaw detection at the end of the tenth cycle. Several coatings ex-

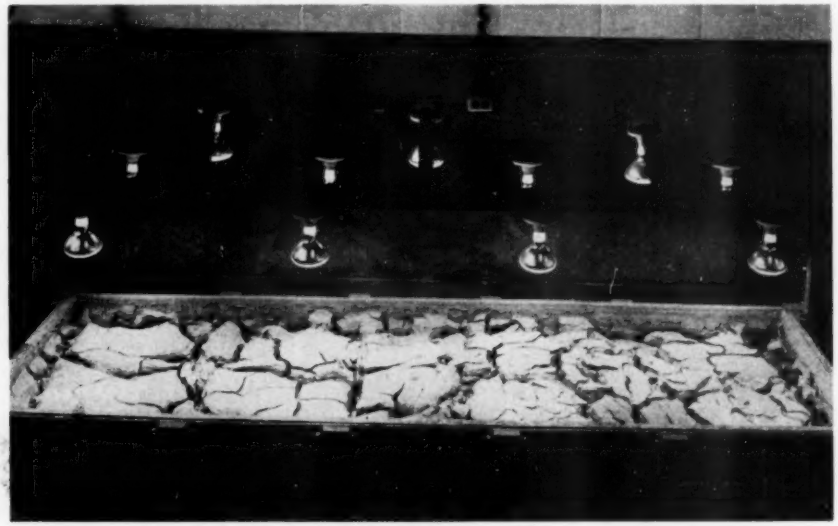


Fig. 4. Condition of Clay After Drying in Soil Box Test

The clay is thoroughly dry and extensively cracked after the 2-week drying period.

posed to less than ten cycles are so designated. The defects found at the end of the last cycle are described. The results of 10,000-v electrical detection on areas subjected to the indentation test are also listed.

Coal-tar enamel coatings, regardless of penetration, applied without reinforcement or wrap, were deeply fissured in the first cycle of wetting and drying in the clay soil test. They failed electrical detection in both the soil stress test and the indentation test. Figure 6 shows the condition of an 8-penetration, coal-tar-enamel coating initially, and at the end of various cycles.

When coal-tar enamel was covered with whitewash, only slight surface checking of the enamel developed. The specimen passed electrical detection after ten cycles in the soil test but failed the indentation test. Inasmuch as the whitewash was removed in handling, it was renewed after each cycle. This practice would not be followed in actual service. It is apparent that whitewash provides a temporary protection against soil stress, but the effect could not be expected to be permanent.

The condition of 8-penetration coal-tar enamel covered with bonded crinkle kraft paper wrap, as shown in Fig. 7, indicates that the paper also provides temporary protection. Most of the paper has been removed by action of the soil after ten cycles, and it is expected that deterioration of the enamel, to which the clay from now on will bond more firmly, will be more rapid in future cycles. Much of the enamel bead at the kraft overlap is disbonded. There are cracks under the disbonded

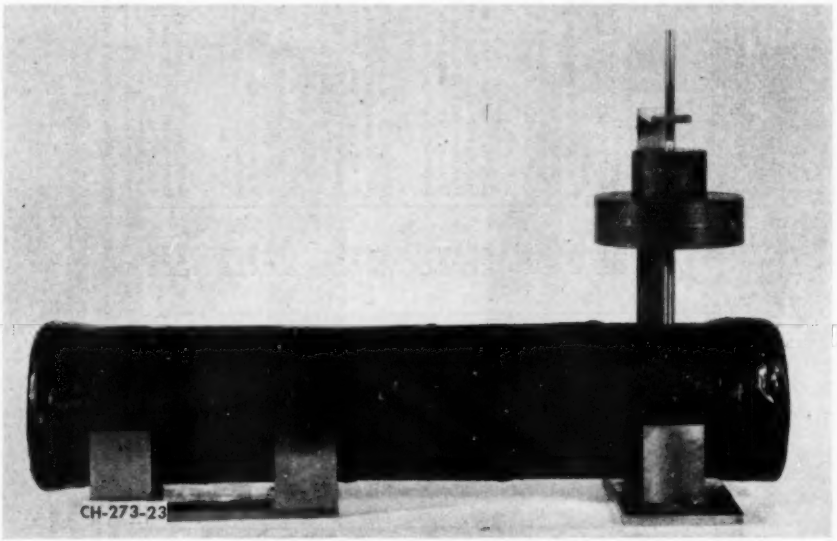


Fig. 5. Indentation Test Apparatus

This test is used to evaluate the resistance of coatings to puncturing by rocks in backfill. Coatings are subjected to a load of 6.48 lb bearing on 0.049 sq in.

TABLE 3

Performance of Exterior Pipe Coatings and Wraps in Clay Soil and Indentation Tests

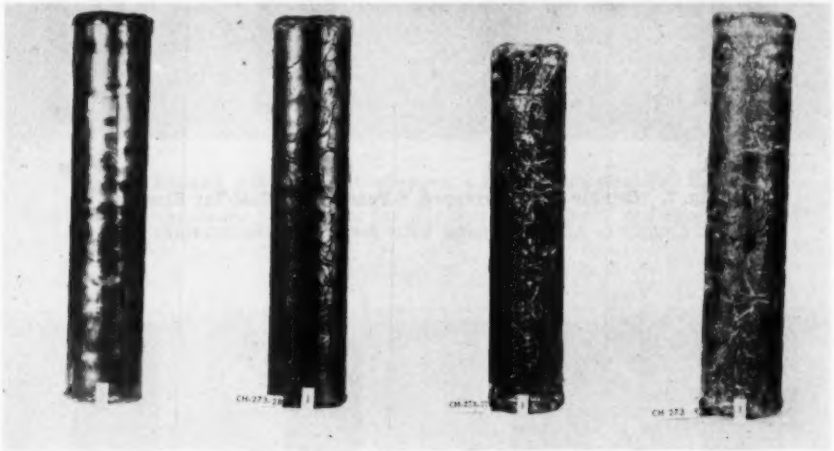
Coating System*	Average Dry-Film Thickness *mils*	Detector Test After 10 Cycles	Detector Test After Indentation	Remarks
CTE (8)	130	Fail	Fail	Deep cracks. Bare metal exposed
CTE (8), kraft wrap	120	Fail†	Pass	Bead partially disbonded. Cracks to metal under bead. Kraft eroding
CTE (7), felt, kraft wrap	185	Pass	Pass	Felt disrupted where no bead and where improperly bonded. Kraft gone
CTE (8), whitewash‡	130	Pass	Fail	Slight surface checking
CTE (7), glass mat, CTE, kraft wrap	145	Pass	Pass	Bead partially disbonded. Some cracks under bead. Kraft eroding
CTE (7), glass mat outer wrap	95	Pass	Fail	60% of wrapper peeled to glass core. Bead disbonded
CTE (7), glass mat, CTE, felt, kraft wrap	185	Pass	Pass	Felt disrupted in localized area where no bead. Kraft gone
CTE (8), cement mortar shield	¼ in.	Pass	Pass	Hairline crack in mortar throughout length of specimen
CTE (4)	95	Fail	Fail	Deep cracks. Bare metal exposed
CTE (4), felt, kraft wrap	100	Pass	Pass	Superficial disruption of felt in localized area. Kraft gone
CTE (4), glass mat, CTE, felt, kraft wrap	125	Pass	Pass	No defects. Kraft gone
CTE (4), glass mat, CTE, outer wrap, kraft	145	Pass	Pass	30% of wrapper peeled to glass core. Kraft gone
Asphalt enamel	85	Fail	Fail	Severe cracks and disruption. Bare metal exposed
Asphalt enamel, felt wrap	155	Pass	Pass	Superficial disruption of felt in localized areas
CA-50	25	Fail	Fail	Cracked and alligatored to bare metal
Cement mortar	¾ in.	Pass	Pass	Several hairline cracks
Polyethylene tape (10 mil)	20	Pass	Pass	Slight wrinkling. Not progressive
Vinyl tape (20 mil)	40	Pass	Pass	Slight wrinkling. Not progressive
CTE tape wrap, paper	175	Pass	Pass	Moderate surface wrinkling and disruption
Reclaimed rubber tape§	50	Fail	Fail	Disrupted and cracked
Plasticized gilsonite, glass mat, gilsonite, wrap ‖	70	Pass	Pass	Bead partially disbonded
Plasticized gilsonite, wrap ‖	125	Pass	Pass	Bead partially disbonded
Microcrystalline wax, wrap ‖	140	Pass	Pass	Bead partially disbonded

* Coatings are not listed in order of preference. CTE indicates coal-tar enamel and values in parentheses indicate penetration of enamel.
† Holidays occur in area where Kraft was butted instead of overlapped.
‡ Whitewash renewed after each cycle.
§ Subjected to 5 cycles.
‖ Microcrystalline-wax-impregnated laminated wrapper. Subjected to 9 cycles.

bead, and in these areas the coating failed to pass the holiday detection test. The specimen passed detection after indentation.

Coal-tar enamel of 7 penetration with a bitumen-saturated glass-core outer wrap had approximately 60 per cent of the bitumen peeled off to the glass core. Again, much of the rounded enamel bead had disbonded. In another coal-tar enamel specimen, a glass reinforcing mat was introduced into

1. Coal-tar enamel specimens of 4 and 7 penetration with bonded asbestos felt wraps. The enamel beads were flattened on both specimens by crinkle kraft paper applied over the felt, but the kraft, being bonded only at the beads, was removed before soil stress tests and indentation tests were started. The coating equipment was not fully in adjustment during the coating of the 7-penetration specimen, and enamel beads were not formed at the felt laps



Initial **1 Cycle** **6 Cycles** **10 Cycles**

Fig. 6. Unprotected 8-Penetration Coal-Tar Enamel Coating

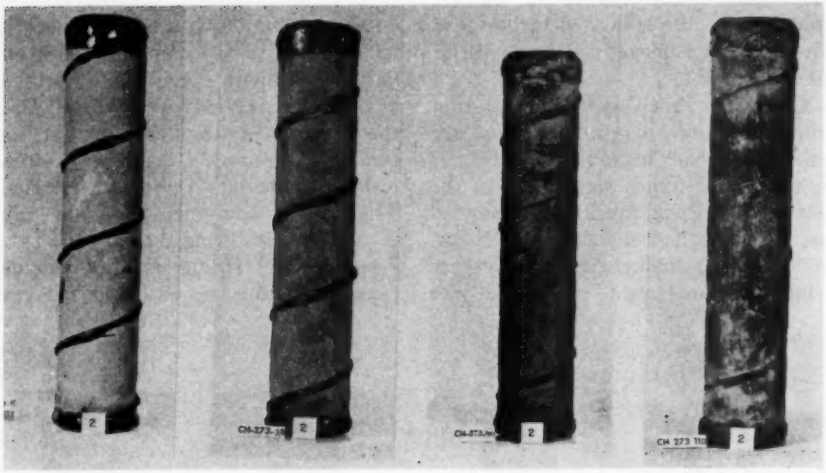
The coating shows severe disruption at the end of 10 cycles.

the system and crinkle kraft paper was applied over the glass-core outer wrap. Both specimens passed the detection test after ten cycles in the soil box. The outer wrap alone failed to prevent indentation, but when the reinforcing glass mat was present, the system passed the indentation test.

All of the following coal-tar enamel coatings passed the 10,000-v detection test after the tenth wetting and drying cycle in clay soil, and also satisfactorily resisted the indentation test:

throughout most of the specimen. Also, at one end, the felt was not properly bonded to the enamel. The soil stresses disrupted the felt where it was not bonded to the enamel and there was some disruption in areas of the overlap where no beads were formed (Fig. 8). When the felt was well bonded and a flattened bead developed on the 4-penetration specimen, however, there was no significant distress (Fig. 9).

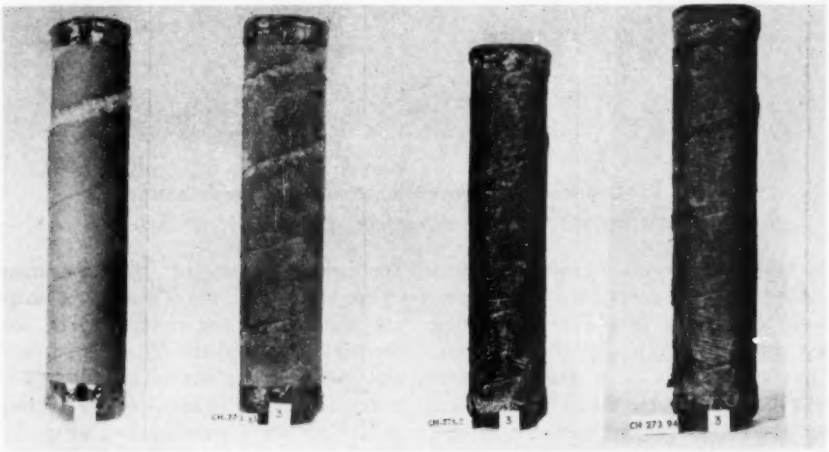
2. Glass-mat reinforced, 7-penetration coal-tar enamel with a bonded



Initial 1 Cycle 6 Cycles 10 Cycles

Fig. 7. Crinkle Kraft–wrapped, 8-Penetration Coal-Tar Enamel

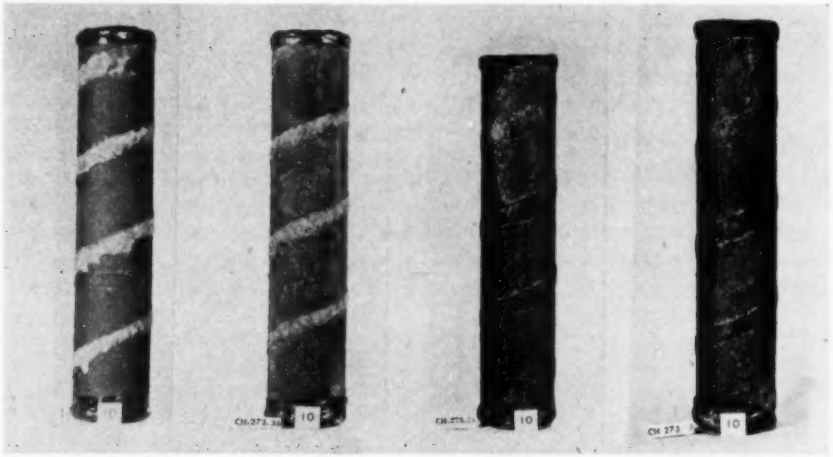
Cracks to the bare metal have formed at the overlaps.



Initial 1 Cycle 6 Cycles 10 Cycles

Fig. 8. Bonded, Asbestos Felt–wrapped, 7-Penetration Coal-Tar Enamel

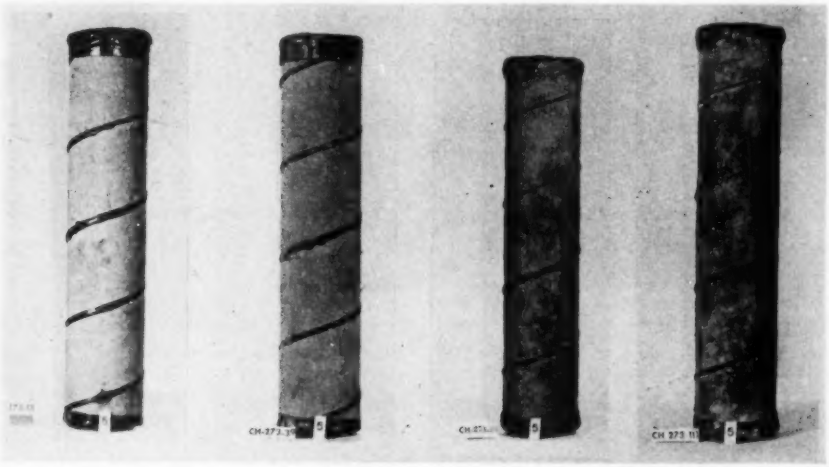
The felt shows disruption where poorly bonded.



Initial **1 Cycle** **6 Cycles** **10 Cycles**

Fig. 9. Bonded, Asbestos Felt–wrapped, 4-Penetration Coal-Tar Enamel

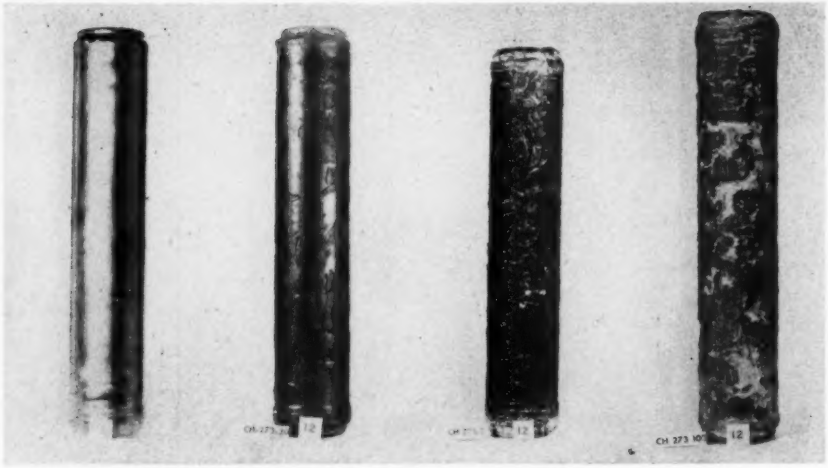
There was no significant distress, as the felt was well bonded and properly beaded.



Initial **1 Cycle** **6 Cycles** **10 Cycles**

Fig. 10. Glass-reinforced 7-Penetration Coal-Tar Enamel With Crinkle Kraft Wrap

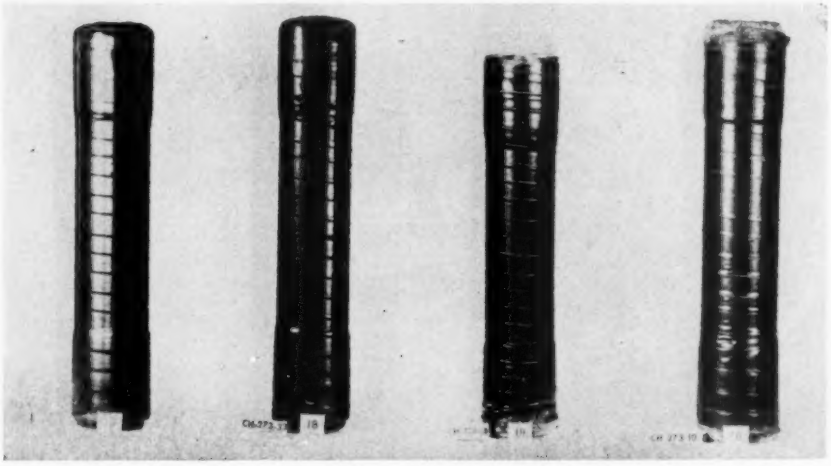
There were cracks but no holidays under the disbonded bead.



Initial **1 Cycle** **6 Cycles** **10 Cycles**

Fig. 11. Unprotected Asphalt Enamel

Severe disruption and exposure of bare metal occurred by the end of 10 cycles.



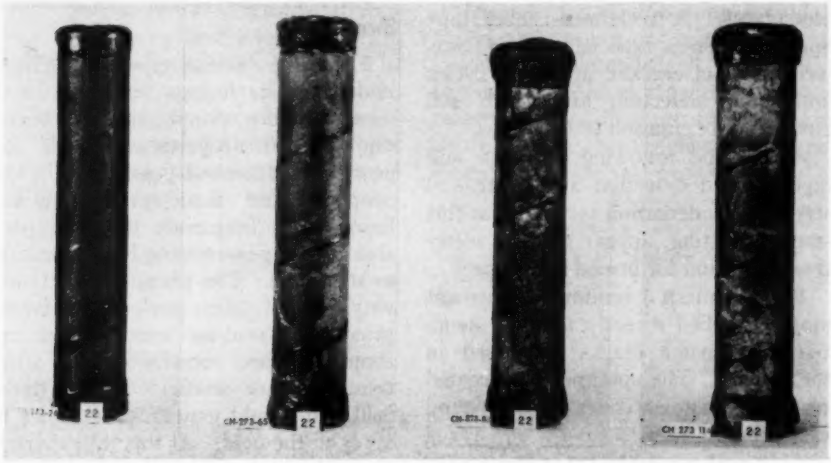
Initial **1 Cycle** **6 Cycles** **10 Cycles**

Fig. 12. Vinyl, 20-mil Tape

This material was practically unaffected after 10 cycles.

kraft wrap. Approximately half of the bead at the kraft overlap had become disbonded in ten cycles of soil stress. There were cracks, but no holidays, under the disbonded bead (Fig. 10). Apparently the glass-mat reinforcement is effective in preventing cracking through to base metal.

3. Glass-mat reinforced, 4- and 7-penetration coal-tar enamel specimens with asbestos felt and kraft wraps. There was no deterioration of felt or



Initial **1 Cycle** **6 Cycles** **10 Cycles**

Fig. 13. Microcrystalline Wax With Wax-impregnated Laminated Wrapper

Approximately 5 per cent of the raised bead was disbonded and some of the threads in the wrapper were disrupted.

of the flattened beads at the felt overlaps. The loosely bonded kraft paper deteriorated in the first few cycles. The one place where a bead was not formed on the 7-penetration, glass-mat reinforced, coal-tar enamel specimen showed slight disruption of the felt.

4. Coal-tar enamel, 8-penetration, with a $\frac{3}{4}$-in. coating of wire-mesh reinforced cement mortar applied pneumatically. One longitudinal hairline crack developed in the mortar throughout the length of the specimen. White-pigmented curing compound was applied over the cement mortar.

A review of the preceding results on coal-tar enamel coatings indicates that soil stress has a severe effect on unprotected coal-tar enamel coatings of either 4 or 7 penetration. A well-bonded felt wrap appears to preserve the integrity of enamel coatings in wetting and drying clay soil. The tests indicate that the felt and felt laps must be well bonded. Rounded beads at the laps of wrappings are readily disrupted and may cause weakening of the coating. Beads should be flattened by a final application of kraft paper. Disruption of enamel appears to be halted by glass-mat reinforcement.

Asphalt enamel with and without felt wrap acted in a manner similar to its coal-tar enamel counterpart, except that the unwrapped asphalt coating showed more extensive deterioration and permitted greater exposure of metal (Fig. 11). When protected with asbestos felt, the asphalt enamel performed satisfactorily. Cold-applied coal-tar paint, CA–50, showed holidays after both soil stress and indentation tests. It cracked and alligatored in the soil test, exposing the metal in numerous places. A reclaimed-rubber tape applied over a special primer was wrinkled and cracked after five cycles and failed detection after both soil stress and indentation tests.

All of the following coatings and tapes passed detection after both soil stress and indentation tests and, at this stage of testing, appear to offer effective protection for buried steel pipe:

1. Wire-mesh reinforced cement mortar applied directly to bare metal. Several hairline cracks developed in the mortar. The specimen was coated with white-pigmented sealing compound for curing.

2. A coal-tar enamel tape wrap with a glass core, flame softened and hand wound over coal-tar primed and coal-tar enameled surfaces representative of a pipe joint. The tape showed moderate surface wrinkling and disruption.

3. Polyethylene tape, 10 mil, double-wrapped cold over three types of surfaces—sandblasted, coal-tar primed, and coal-tar enameled. The tape showed only very slight, localized wrinkling, which was not progressive. Similar results were obtained with a vinyl, 20-mil tape (Fig. 12).

4. Microcrystalline wax with a wax-impregnated laminated wrapper. Approximately 5 per cent of the raised bead was disbonded (Fig. 13). Also, some of the threads of the tobacco cloth in the wrapper were disrupted. The manufacturer advises that the tobacco cloth is used mainly to provide strength for the wrapper during the application. Similar results were obtained with two plasticized gilsonite specimens, one with and one without glass-mat reinforcement, but both provided with a microcrystalline wax impregnated, laminated outer wrap.

Summary

1. Of the various types of coatings under test as linings for steel water pipe, phenolic, vinyl, thiokol, vinyl-thiokol, and neoprene materials appear to offer the best possibilities. The neoprene and flame-sprayed thiokol linings may frequently be too expensive and time-consuming for application to steel pipe. The phenolic, vinyl, and vinyl-thiokol paints are competitive in price with coal-tar enamel, and are sometimes less expensive. In addition, they are unaffected by extreme cold and would generally be easier to apply in the field. At this time there is no evidence that any of these coatings will prove more durable than coal-tar enamel in the usual exposures that are encountered.

2. The low-temperature (− 41 F) field exposure tests have shown that coal-tar enamel linings must be plastic to withstand cracking and disbonding in cold weather. Enamel of 9–10 penetration as applied resisted − 41 F. Enamel of 7 penetration was slightly damaged at − 41 F but will probably withstand − 20 F. The harder the enamel is below 7 penetration, the more certain it is that it will crack and disbond in cold weather.

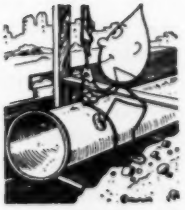
3. In formulating cement mortar as a lining material, it is important to provide against drying shrinkage unless the lining is to be kept continuously wet in service. Success in this direction has been realized by employing an air-entraining agent and preshrinking the mortar before applying.

4. A substantial wrapping over coal-tar enamel is indicated to be essential to long-life protection in clay soils. Wrapping is probably a worth-while safeguard for most buried pipe regardless of soil conditions, because, if wetting and drying soil stress does not damage the unprotected coating, it is still vulnerable to puncturing by rocks or hard clods under the weight of backfill. It is important that the wrapper be completely bonded to the hot enamel to avoid disruption by soil stress. It is also important to form a bead at the overlaps and to flatten the bead with a kraft paper wrapping. Otherwise, soil stress will disrupt the wrap at the overlaps.

5. The new cold-applied vinyl and polyethylene tapes appear to be satisfactory for protecting buried pipe and would seem especially appropriate for use on welded field joints.

Acknowledgment

The assistance of coating manufacturers and applicators in these tests is gratefully acknowledged. Industry, through new developments in coating materials and willingness to furnish and apply these materials, has, to a large extent, made the test program possible.



Ductile Iron—A New Engineering Material for Water Works Construction

By C. T. Haller

A contribution to the Journal by C. T. Haller, Metallurgist, Development & Research Div., The International Nickel Co., Cincinnati, Ohio

WITHIN the last four years, the commercial production of an entirely new foundry product was begun and has now grown to the status of a commercially available material. It is the purpose of this paper to present some of the features of this product, variously known as ductile iron, magnesium-containing iron, spheroidal graphite iron, and, occasionally, nodular iron. The product was first discussed in May 1948 by Wickenden (1). The product was announced to the foundry industry in Feb. 1949 (2), and patents were granted on Oct. 5, 1949 (3).

A piece of high-carbon steel (SAE 1095 drill rod) approximately ½ in. round can be used to illustrate roughly the essential difference between ductile iron and gray iron (4). When this piece of steel is struck by a swinging hammer, no failure occurs even at the full capacity of the hammer, which supplies 220 ft-lb of energy. The same piece of steel with a small notch in it will react differently. The hammer breaks the high-carbon steel employed in this test with an energy expenditure of 3 ft-lb. These tests show a ratio greater than 70:1 between the notched and unnotched specimen. The second piece behaved in a brittle manner because of the presence of the notch, even though both samples had the same chemical composition.

Internal Structure

Photomicrographs of the internal structure of gray iron and ductile iron are shown in Fig. 1 and 2. The internal structure of the metal illustrates the difference between gray iron—including high-strength gray iron, sometimes called semisteel—and ductile iron. It may be observed that the very weak graphite constituent appears in gray iron (Fig. 1) as a semicontinuous network of flakes. In other words, the graphite flake may be likened to the notch in the high-carbon steel specimen previously described. Because of the large surface area of the graphite flake and its semicontinuous nature, the path of fracture, or the crack, actually will follow these flakes. The appearance of the graphite on the face of the resulting fracture surface is what has given this iron the name "gray iron."

The weak graphite constituent of ductile iron (Fig. 2) appears as isolated spheroids in a continuous matrix. The fracture of the ductile iron, as it cannot follow any continuous path of graphite, resembles the fractured surface of a coarse-grained steel. It is not difficult to predict what effect this

difference in graphite form and distribution will have on the physical characteristics of the casting.

Properties

Not only does the notching effect of the graphite flake make it impossible to obtain more than 0.5 per cent elongation in gray iron, but it also lowers the tensile strength as compared with iron having spheroidal graphite. High-strength gray iron is being regularly produced with a tensile strength minimum of 50,000 psi, and strengths in excess of 75,000 psi have been measured. An elongation of 0.5 per cent has sometimes been measured in gray iron, but the failure is brittle in the sense that there is no flow of metal or permanent plastic deformation before breakage occurs. In contrast, an iron containing spheroidal graphite is being consistently produced to a minimum tensile strength specification of



Fig. 1. Microstructure of Cast Gray Iron Containing Flake Graphite

The very weak graphite constituent appears as a semicontinuous network of flakes. A magnification of 750 × was used.

60,000 psi with an accompanying minimum elongation of 10 per cent. At strength levels in this range, elongations up to 25 per cent have been recorded. By quenching and drawing, tensile strengths approaching 200,000 psi have been obtained (5, 6).

Ductile iron will vary in hardness in the as-cast condition depending upon the analysis of the iron and the cooling rate or section size. Figure 4 (8) is representative of the average properties of a large number of test bars. As the hardness increases, the strength increases, and the elongation drops. The analyses tested covered a wide range of carbon and silicon. Usually the phosphorus content was less than 0.08 per cent and the manganese less than 0.40 per cent. At a hardness of 160

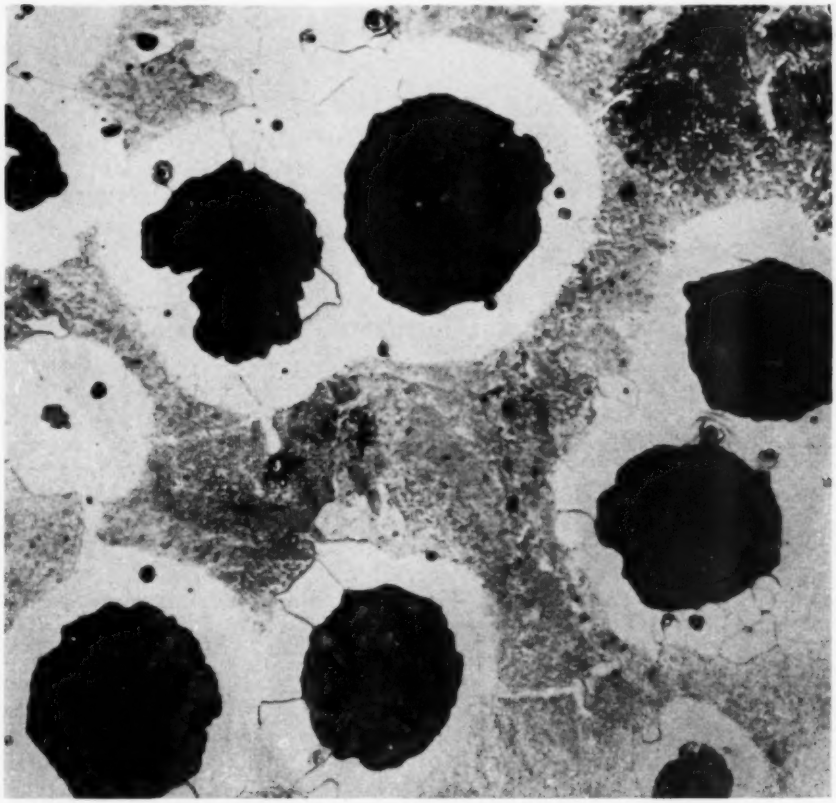


Fig. 2. Microstructure of Ductile Iron Containing Spheroidal Graphite

The weak graphite constituent appears as isolated spheroids in a continuous matrix. A magnification of 750 × was used.

Figure 3 illustrates the ductility of iron containing spheroidal graphite (7). These specimens are approximately ¼ in. square and were machined from the wall of an 8-in. ductile-iron pipe.

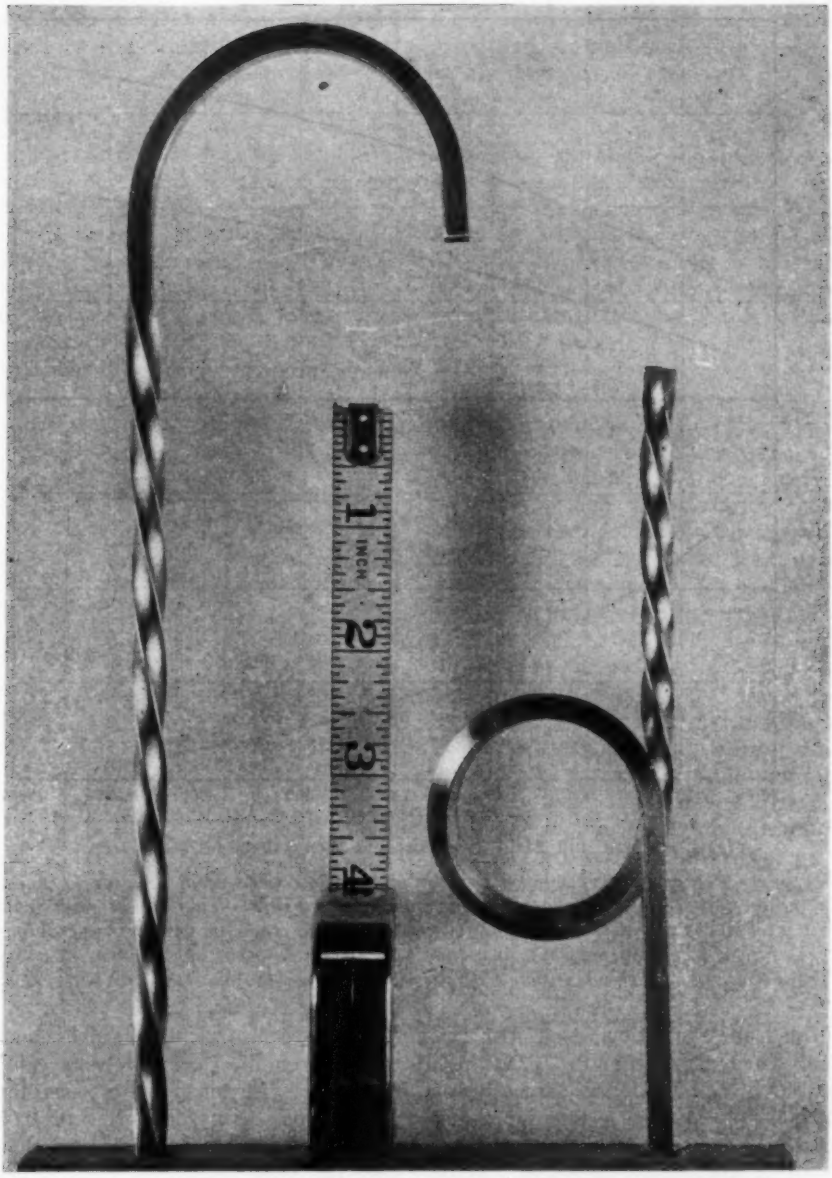


Fig. 3. Twisted Specimens of Ductile Iron

The specimens are approximately ¼ in. square and were machined from the wall of an 8-in., ductile-iron pipe.

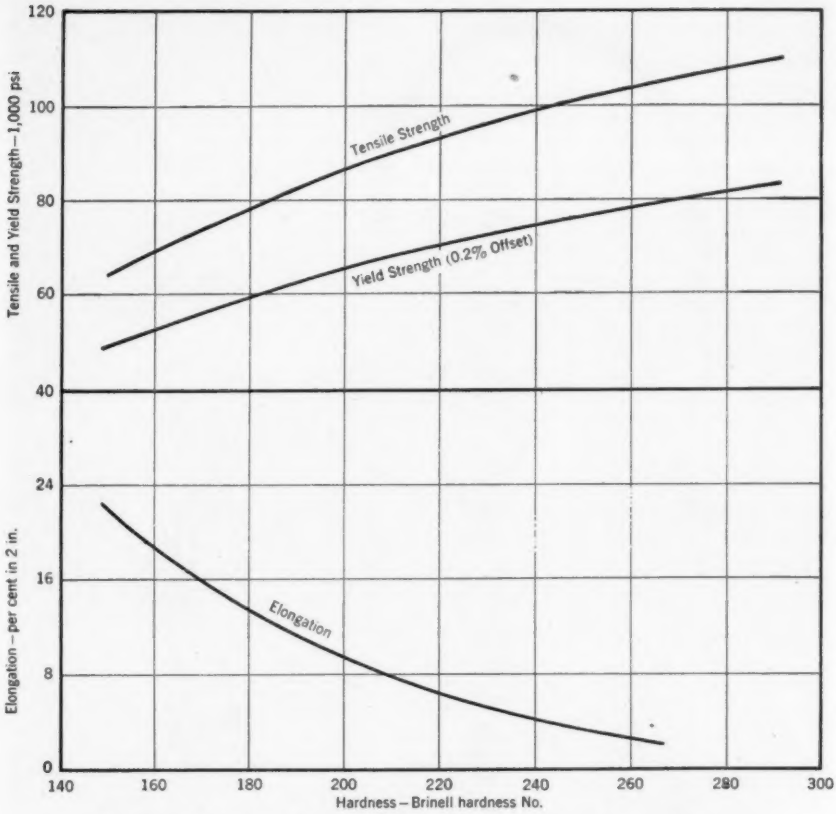


Fig. 4. Tensile and Yield Strengths and Elongation of Ductile Iron

The average properties of a large number of test bars were used. As the hardness increases, the strength increases and the elongation drops. The as-cast data from 1-in. keel blocks included irons of the following range of analysis: carbon 3.30–3.80 per cent; silicon 2.20–2.80 per cent; manganese 0.25–0.75 per cent; phosphorus 0.10 per cent maximum; sulfur less than 0.02 per cent; and magnesium 0.06–0.09 per cent.

Brinell, the elongation was 17 per cent and the tensile strength 70,000 psi; at 260 Brinell, the tensile strength was 105,000 psi and the elongation 3 per cent.

In a completely annealed ductile iron, the properties are determined chiefly by the amount of silicon and partially by the amount of phosphorus. Figure 5 compares the hardness and tensile strength of completely annealed irons (9). In this series of tests, the phosphorus was never more than 0.05 per cent nor the manganese more than 0.40 per cent. Roughly, each 1 per cent of silicon raises the tensile strength by 11,000 psi and decreases the elongation by 3 per cent. In fully annealed

ductile iron, the carbon is present entirely in graphite spheroids. No combined carbon can be observed.

Production

The essential step in the production of iron containing spheroidal graphite is the introduction of a small but effective amount of magnesium into a typical gray-iron analysis. The final magnesium content is approximately 0.05 per cent or 1 part in 2,000. This very small amount of magnesium is sufficient to produce a material having the combination of high strength and good ductility previously described.

The high-tensile properties and the presence of some ductility, together with the fact that it may be produced in a gray-iron foundry, have led, even at this early date, to a number of industrial applications of ductile iron. Castings varying in size from small electrical hardware fittings to 100,000-lb anvil blocks have been produced to take advantage of the characteristics of ductile iron (10, 11).

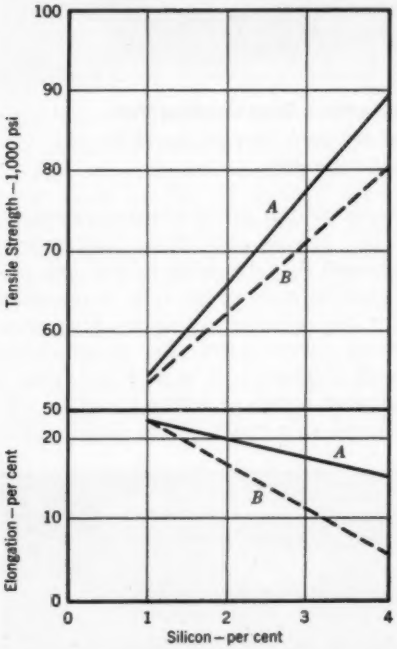


Fig. 5. Tensile Strength and Elongation of Annealed Ductile Iron

The silicon content was varied, but the phosphorus was never more than 0.05 per cent nor the manganese more than 0.40 per cent. Line A *represents a 1-in. section of ductile iron, and Line* B *a 6-in. section.*

Application

A large tonnage of ductile iron pipe has been produced, although the application of this pipe is still in the experimental stage. The attractiveness of this product for use in pipe results from its high wall and bursting strength combined with some ductility. There are two approaches to the use of ductile iron in pipe: one is the use of ductile iron in the same wall section as gray iron for those points at which the higher strength and the much greater resistance to bursting is desired; and the other is that of drastically cutting down the wall thickness and taking advantage of the lower transportation costs and greater ease of handling of a lighter pipe. Figure 6 (7) compares a ductile-iron and a gray-iron pipe section in a ring crushing test. The average ring modulus of rupture on 8-in. diameter rings was 127,650 psi, compared with 55,000 psi for gray iron pipe as now made. The bursting tensile strength of ductile iron is 52,000–62,000 psi, as compared with 22,000 psi for present iron pipe. Figure 7 shows some pipes that were given a bursting test. These pipes were arc-welded with a high-nickel iron rod. The bursting strength of the welded pipe remained high and fracture oc-

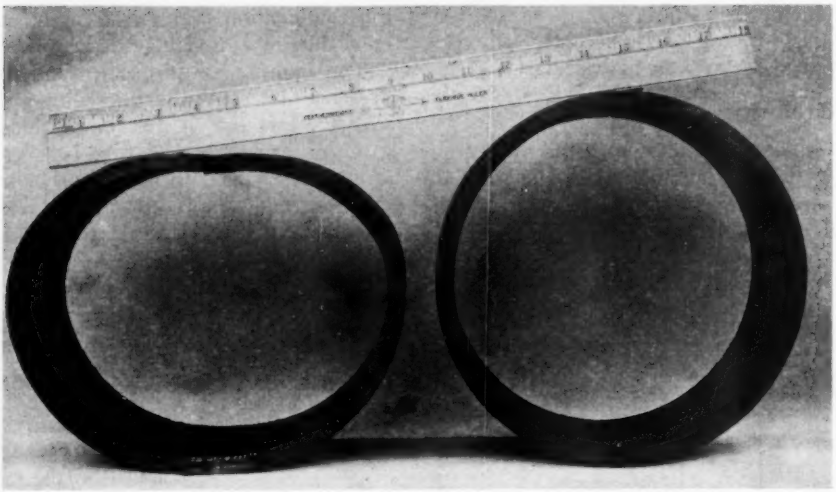


Fig. 6. Ductile Iron and Gray Iron After a Ring Crushing Test
The ductile iron is on the left and the gray iron on the right. Both rings were cut from pipe.

curred outside the weld area. The pipe actually bulged some time before final bursting occurred. The average bursting pressure was 5,300 psi. Gray-iron pipe tested in the same manner broke at 2,400 psi and shattered. Employing ASA pipe-designing formulas, calculations were made of the required metal thickness for ductile iron pipe to be used at given working pressures. The results of these calculations showed that the metal in the pipe wall could be reduced by at least one-third for any given class or working pressure. Even after this reduction in wall thickness, it was found that a greater factor of safety could be employed as a result of the high level of



Fig. 7. Bursting Test on Welded Pipe
Pipes were arc-welded with a high-nickel iron rod. Failure occurred through the wall, not the rod.

TABLE 1

Corrosion Data

Solution	Duration *days*	Temp. °F	Ductile Iron		Gray Iron	
			As Cast	Annealed	As Cast	Annealed
Aerated tap water	28	86	0.025	0.020	0.035	0.028
Rapid motion sea water	4	60	0.058		0.060	
Aerated 3.5% NaCl	28	86	0.025	0.016	0.027	0.021
Aerated 5% H_2SO_4	1	86	8.7	4.1	6.5	8.2
5% NaOH	9	260	0.018	0.018	0.017	0.022
	+10	70				

physical properties of the iron in the pipe.

Figure 8 shows ductile-iron pipe fittings that have been tested extensively by Underwriters Laboratories, Inc. Elbows ¾, 1, 1¼, 1½, and 2 in. in size were tested with a hand-operated pressure pump. Except for two tests that showed very minute seeping at the joint, none of the 25 fittings tested failed or leaked at a pressure of 5,000 psi, the capacity of the test equipment. These test fittings were cast with the dimensions of a 150-lb malleable iron screw fitting and are covered by specification ASA B16C. As a result of this test, the lighter ductile-iron fittings were approved by the Underwriters Laboratories' report for the heavier 300-lb malleable fittings service. Details of the dimensions of the 300-lb malleable may be found in specification SP–31–1944 issued by the Manufacturers' Standardization Society of the Valve and Fittings Industry. In the same report, these fittings were approved for use in water piping of automatic sprinkler, open sprinkler, water spray, and standpipe equipment.

This ability to withstand much higher pressures and to fail with some plastic deformation rather than shattering has led to its commercial use in a number of applications. Figure 9 shows a casting of ductile iron—a large cylinder for one of the leading builders of hydraulic presses. The properties of ductile iron are now being investigated by a number of manufacturers supplying equipment to the water distribution industry. Some of these parts are pipeline joints. The high strength



Fig. 8. Black and Galvanized Ductile-Iron Fittings

The galvanized fittings are on the left and the black on the right. These elbows have been extensively tested with a hand-operated pressure pump.



Fig. 9. Casting of Ductile Iron
This cylinder was made for a hydraulic press.

of ductile iron is probably the most important factor leading to its consideration for this application.

Ductile iron has also been considered by municipalities that have reported some breakage of gray iron in the frames and inner-cover castings of manhole assemblies. This breakage occurs primarily on installation as a result of workmen's overtightening the bolts. There has been some interest in use of ductile iron for parts such as valve body assemblies, blind blockoff flanges, and fire hydrants in which resistance to shock is a factor. Ductile iron has been considered, too, as a replacement for gray cast iron that sometimes fails because of water hammer and vibration. Other possibilities include pipe that is subject to shock or heavy loading, cofferdams, and some culvert construction parts.

There is reason to believe that iron containing spheroidal graphite is somewhat more resistant to failure from graphitic corrosion than is gray iron.

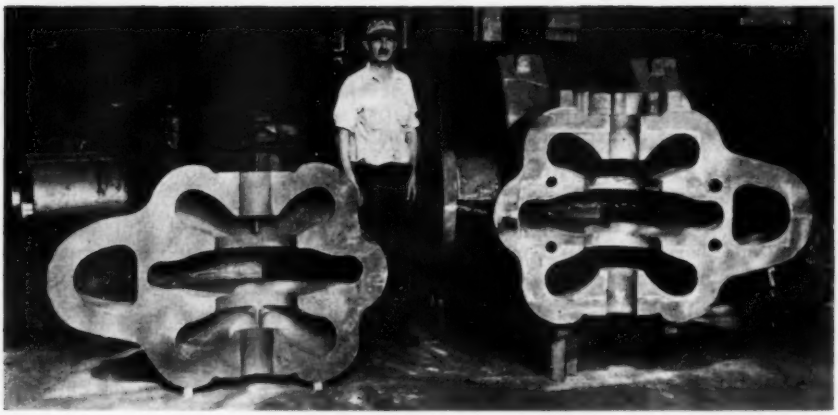


Fig. 10. 10,000-lb Ductile-Iron Pump Casing for Water Works Service

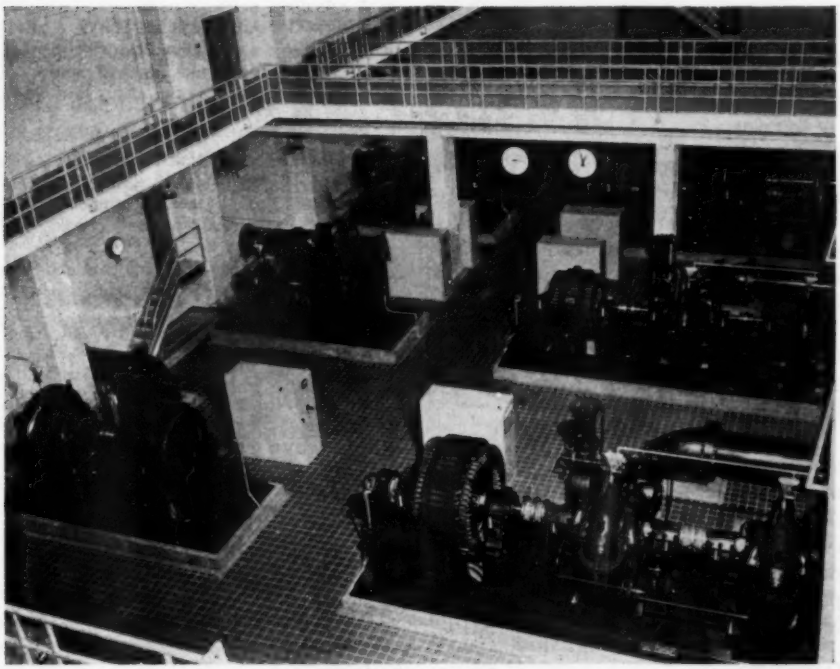


Fig. 11. Pumping Installation Using Ductile-Iron Casings

The pumps in this installation used ductile-iron casings like that shown in Fig. 10.

This assumption is based upon the importance of surface area in galvanic corrosion. Graphitic corrosion results from galvanic action between the graphite surface film and the steel matrix. Inasmuch as spheroidal graphite has less surface area for the same volume, one would expect ductile iron to be more resistant to attack by graphitic corrosion. In overall corrosion resistance, there does not seem to be much difference between iron containing flake graphite and iron containing spheroidal graphite. Table 1 gives the results of a few comparative corrosion tests.

TABLE 2

Specification for Ductile Iron

	Grade (80–60–03)	Grade (60–45–10)
Min. tensile strength—*psi*	80,000	60,000
Min. yield strength—*psi*	60,000	45,000
Min. elongation in 2 in.—*per cent*	3.0	10.0

Another characteristic of ductile iron is its relatively good machinability (12). This characteristic, as well as its high strength and ready castability, has led to its selection in the large pump casing casting shown in Fig. 10. Figure 11 shows a pumping installation at which a number of pumps of the type using a ductile iron casing are in service.

Figures 4 and 5 have shown the results of a number of tests on ductile iron. These figures represent actual tests, and a certain leeway must, of course, be allowed for day-to-day production. Table 2 gives the minimum property specifications provided by tentative standard ASTM A–399–51T.

Conclusion

The combination of good fluidity, high yield and tensile strength, and toughness has led to numerous commercial applications of ductile iron since the original announcement of the development in 1948. Production in 1951 was three times higher than in 1950, and there is every expectation that this rate of growth will continue as increasing use is found for the unique combination of properties provided by this new engineering material.

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Soil Temperatures in Water Works Practice

By R. F. Legget and C. B. Crawford

A paper presented on May 26, 1952, at the Canadian Section Meeting, Montreal, Que., by R. F. Legget, Director, and C. B. Crawford, Asst. Research Officer, both of the Div. of Building Research, National Research Council, Ottawa, Ont.

THE variation of the temperature of the soil, throughout the year and at different depths below ground surface, might seem to be a scientific curiosity of little practical interest to the water works engineer until the relation of soil temperature to the freezing of water pipes is appreciated. The freezing of water in buried mains is due, largely, to the cooling of the surrounding soil below the freezing point of water. This cooling is but one particular feature of a general pattern of the changing soil temperature profile as the effect of winter air temperatures is felt beneath the surface of the ground.

Soil temperature variations are unusually complex, and have a wide practical significance. They affect the performance of buried pipes used for the passage of fluids which freeze at normal temperatures, and are clearly a determining influence in the performance of heat pumps. Soil temperature variations are related to the flow of heat in the ground, and thus influence heat losses from the basements and foundations of buildings, the performance of cold storage buildings, and the innumerable problems associated with foundation designs. Frost-boil and associated difficulties in road and airfield construction are further evidences of changing soil temperatures.

Canada's Div. of Building Research, National Research Council, is keenly interested in this important natural phenomenon. The initial studies of the senior author were begun in 1943, and were transferred to Ottawa at the start of the work of the Div. of Building Research in 1947. There were serious snow and ice problems in Ottawa the following winter, which resulted in difficulties in water main maintenance. The division was consulted by the Works and Water Works Commissioners of Ottawa about these difficulties. As the Ottawa problems were closely linked to the more general soil temperature studies already being conducted by the division, a cooperative program was developed. This paper represents the first public progress report upon the work.

Many variables are encountered in soil temperature studies, one of which is the weather. Ironically, the winters in Ottawa since this cooperative work started have not been exceptionally cold and there has been no opportunity to study extreme conditions. As the time unit in all soil temperature work is one year, and as weather is not yet susceptible to control, this limitation upon experimental work must be accepted, but the reporting of results cannot be delayed too long if they are to be of general interest. This paper

represents a sharing of experience to date rather than a finished statement of specific results. The authors feel that the information which has been developed will be of assistance to water works engineers in solving maintenance problems.

at Ottawa is 42 F, and the mean soil temperature at 20 ft is approximately 48 F. Ground temperatures near the surface, however, must naturally vary greatly throughout the year.

Figure 1 shows the general pattern of soil temperature in the upper 20 ft

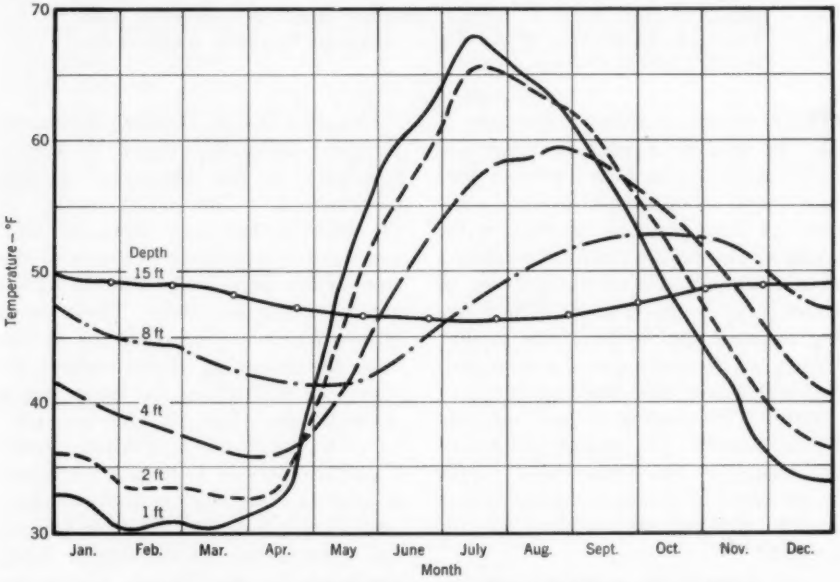


Fig. 1. Temperatures in Undisturbed Clay With Natural Snow Cover

The temperatures were recorded in Ottawa for the year 1950 by means of sensitive measuring devices inserted into minute holes formed in the sides of a pit.

Soil Temperature Variations

If accurate measurements of the temperature in the ground are made and recorded throughout a year, it will be found that there is no appreciable variation in temperature below a depth of approximately 20 ft. The steady temperature at this depth is usually slightly above the mean annual air temperature for the locality, as is the usual temperature of ground water—for example, the mean annual air temperature

of the earth's crust, which is the region of interest to water utilities. The main features are a rapid decrease in the range of temperature, and a steadily increasing time lag, both varying with depth. The time lag, which is due to the slow transfer of heat through the ground, eventually reaches approximately six months at a depth of 20 ft in Ottawa. Thus, the coolest spot in Ottawa in mid-August is 20 ft below the surface of the ground, where the

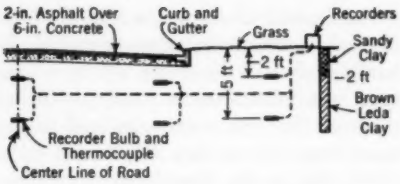


Fig. 2. Installation of Temperature-Recording Instruments in Ottawa

The instruments are automatic, mercury bulb, and were installed under two city streets, 2 and 5 ft under the center of the street, the gutter, and the boulevard.

full effect of the previous winter is just being experienced.

This pattern of soil temperature variation is an understandable one and for homogeneous soil conditions can be determined by calculation, using certain simplifying assumptions. The pattern shown in Fig. 1 is based on records taken in undisturbed ground. This means, in practice, that the records of temperature have been taken by means of sensitive measuring devices inserted into minute holes formed in the sides of a pit, and long enough horizontally to eliminate the effects of the disturbance of the soil in the pit. For such conditions, and with undisturbed snow cover, it has been found that frost penetration is much less than is generally supposed.

Some of the factors which influence soil temperature include: the state of the soil, whether disturbed or undisturbed; the type of soil; the state of the snow cover, whether disturbed or undisturbed; the nature of the ground surface; and the moisture content and thermal properties of the soil. All these factors may influence the soil temperature profile throughout the year, particularly in the upper few feet, the critical few feet from the point of view of the water works engineer. Agricultural soil scientists have studied extensively the effect of these factors in the top few inches of the soil profile, and some engineering studies have been made. The junior author has made a detailed analysis of the engineering literature in this field (1).

As would be expected, the engineering literature emphasizes the overriding influence of the annual variations in air temperature. The character of the surface cover is also an important factor, particularly the insulating value of undisturbed snow, but this is an uncertain quantity as snow can and does vary so much with time. The type of soil is naturally important, but the degree of disturbance as represented by its density relative to its undisturbed density is perhaps the fac-

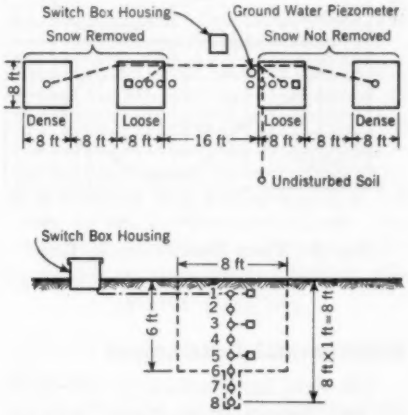


Fig. 3. Installation of Temperature-Recording Instruments at Montreal Road Laboratories

This installation was planned for a theoretical study of air temperature, snow cover, density of soil, type of soil, and disturbance of clay soils. ○ represents a thermocouple and □ a moisture-measuring unit.

tor of greatest significance. The presence or absence of ground water within the top few feet is another important factor. Thus it can be seen that any statements about the depth of frost for any general area can only be approximate and may even be misleading. The excavation of trenches for water main installation automatically introduces a special complication into the local soil temperature condition.

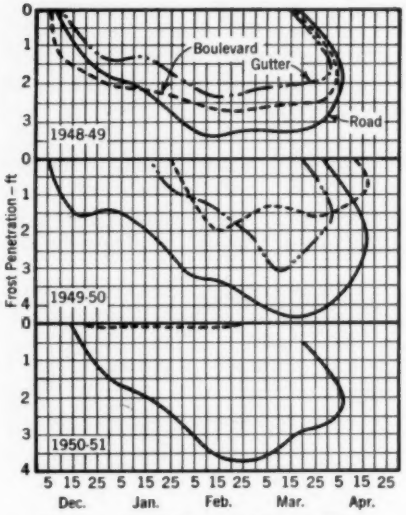


Fig. 4. Frost Penetration in Clay

Measurements were made in Ottawa for the years 1948–51.

Experimental Installations

The field installations for the study of soil temperatures have been described by Legget and Peckover (2) and, therefore, only a general description will be given. In Ottawa, automatic, mercury-bulb, temperature-recording instruments were installed under two city streets in November 1948. The bulbs were placed 2 and 5 ft under the center of the street, the gutter, and the adjoining strips of turf, or boulevard, as shown in Fig. 2. One set of instruments was installed in sandy soil and the other set in a clay type soil. Continuous readings during most of the year were obtained in the sand from November 1948 until June 1950, and in the clay from November 1948 until September 1951.

For a more theoretical study of some of the basic factors affecting soil temperatures under field conditions, two test sites were chosen at the Montreal Road Laboratories of the National Research Council, one site in sand and the other in clay. This project was planned particularly for the study of five variables—air temperature, snow cover, density of soil, type of soil, and disturbance of clay soils. Four test pits, 8 ft square and 6 ft deep, were dug at each site, and each pit was equipped with thermocouples at 1-ft intervals of depth and was backfilled under controlled conditions (Fig. 3).

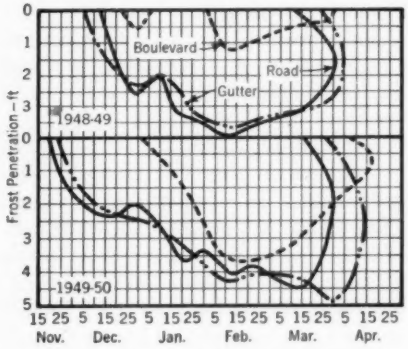


Fig. 5. Frost Penetration in Sand

Measurements were made in Ottawa for the years 1948–50.

Two pits at each location were backfilled loosely and two were made compact with pneumatic tampers. During the winter, one loose and one dense pit

at each site were kept cleared of snow. Measurements are also being made in undisturbed clay to 15 ft below the surface. Temperature readings were begun in December 1949 and are continuing. Moisture meters were installed with the thermocouples, but these have proved to be unsatisfactory. Soil moisture variation is being measured using samples obtained from test borings.

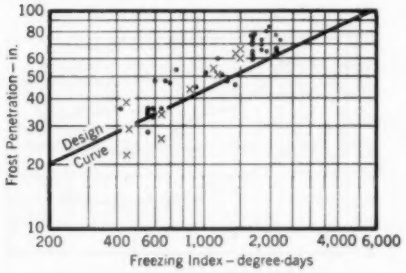


Fig. 6. Frost Depths and Freezing Index in Winter Excavations

The design curve included in the figure was developed by the U.S. Corps of Engineers (3–5) from an analysis of frost penetration records of the northern U.S. ● represents 1947–48 frost depth in unclassified soil. × represents 1950–51 frost depth in sand.

Results in Ottawa

Many difficulties were encountered in the field work. Corrosion of the recorder bulbs at the clay installation in Ottawa made replacement necessary in September 1949, and interrupted record continuity. It was necessary to remove the recorders in the sand when the instruments were damaged by vandals during the summer of 1950. After reviewing the results, it became apparent that three measuring points under the road and three under the boulevard would have given more satisfactory data. Such an installation would have eliminated gutter measurements which were of limited value as it was impossible to control snow cover at the edge of the roadway. Probably the most serious error was the discovery, after installation, that a 12-in. sewer line was located near the measuring bulbs in the sand. This sewer line has complicated the analysis of soil temperatures, but at the same time, has shown how significantly a sewer will

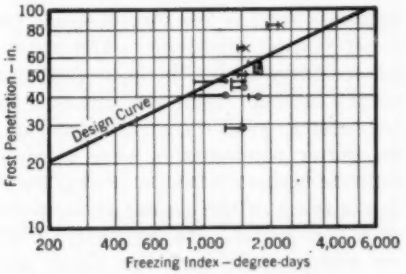


Fig. 7. Maximum Frost Penetration and Maximum Freezing Index

Measurements were made in Ottawa for the years 1947–51. The right-hand end of the horizontal line indicates maximum frost depth at maximum freezing index. The left-hand end indicates freezing index at the time of maximum frost depth. ● refers to measurements made in sand (interpolated); ⊙ clay (interpolated); × sand (by excavation); and + clay (by excavation).

raise the temperature of the surrounding soil.

Nevertheless, some pertinent observations can be made from the records which are shown in Fig. 4 and 5. The frost penetration was generally deepest from mid-February until mid-March, and was considerably greater under the center of the road than under the gutter or boulevard. An exception, probably a result of the sewer, occurred in the sand, where the frost penetration

under the gutter was nearly as great, and at one time greater, than that under the road. The effect of the sewer at the sand installation is evident in Fig. 5. The temperature at the 5-ft depth under the center of the road was consistently warmer than the temperature of the surrounding soil at 5 ft. The reverse occurred at the clay site. As the frost depth was interpolated assuming a linear temperature gradient between 2 and 5 ft, the computed penetration in sand is less than it would be under normal conditions. The winter temperatures under the boulevard are usually warmer than the others. In one winter, 1948–49, at the clay site, the gutter temperatures were warmer than the boulevard temperatures, probably a result of the greater snow cover over the gutter. In February 1950 the trend of the frost line under the gutter and boulevard in the clay suddenly reversed. A transfer of snow from the gutter to the boulevard appears to be a reasonable explanation for this change.

Snow conditions at the clay site were observed during 1950–51. For February these records show an average of 3 in. of packed snow on the road, 3½ ft of snow over the gutter, and 4 in. of snow on the boulevard. During this period, temperatures at the 2-ft depth under the gutter were abnormally high.

Cooler temperatures under the boulevard in clay, during the summer of 1950, illustrate the insulating effect of sod. This insulation is also present during the winter, although probably to a lesser extent. Sod does, however, complicate an evaluation of snow cover alone.

In addition to recording temperatures at these two sites in Ottawa, the Water Works Dept. has recorded frost depths in most winter excavations which have been made since 1947. This record has proved to be valuable, perhaps more valuable to the water works engineer than the measurement of actual soil temperatures, as it gives average values of frost penetration throughout the city rather than values at certain sites that are assumed to be typical. These data are given in Fig. 6, 7, and 8. Figure 6 shows the relation between freezing index, which will be described later, and measured frost

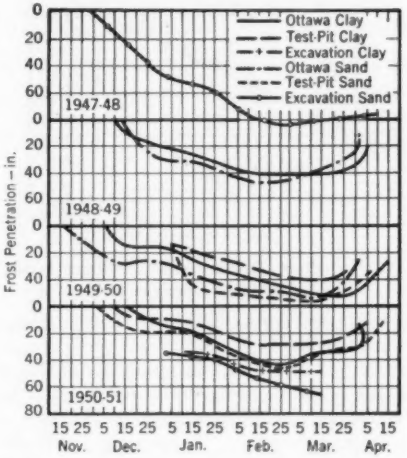


Fig. 8. Approximate Frost Penetration in Ottawa Area

These observations were made when there was no snow cover.

penetration. The "design curve" developed by the U.S. Corps of Engineers (3–5) from an analysis of many records of frost penetration in northern U.S., measured mainly under snow-cleared airport runways on stabilized base course, is also shown in Fig. 6. The values for Ottawa show a trend parallel to the design curve but considerably above it.

The design curve, however, is based on maximum freezing index and maxi-

mum frost penetration for each winter. This relation is shown in Fig. 7, together with the horizontal displacement obtained by showing the freezing index at the time of maximum frost depth. The data are in agreement with the design curve for conservative estimates of frost penetration, except for the frost depths observed in sand excavations. often show maximum frost penetration occurring several weeks before maximum freezing index for the winter. In western Canada the reverse is usually true as maximum frost penetration occurs long after the maximum freezing index. Water mains have frozen as late as June in Winnipeg. The reason for the later occurrence of maxi-

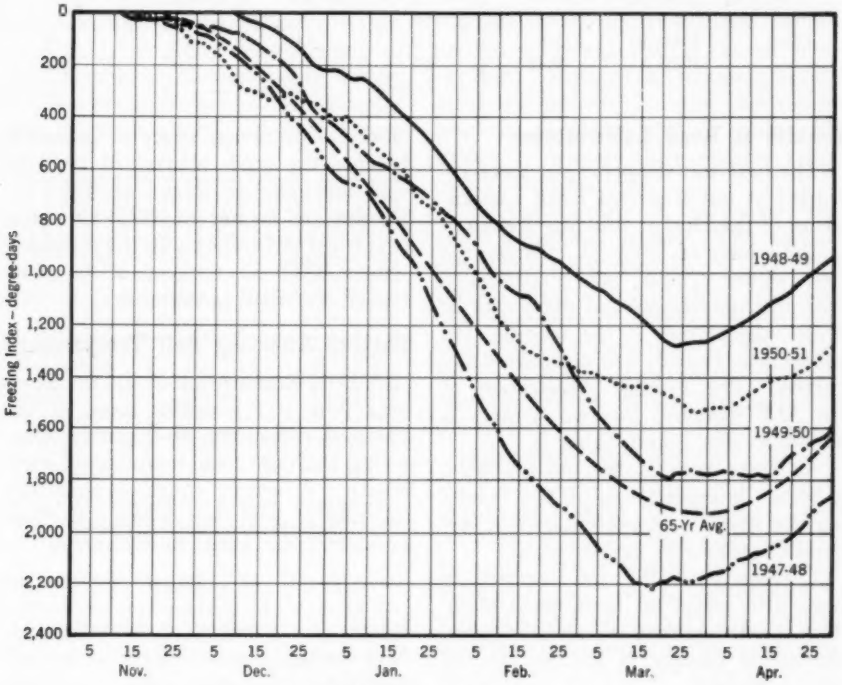


Fig. 9. Cumulative Freezing Index at Ottawa

The upper point at 84 in. penetration occurred during the winter of 1947–48, which appears to have been more severe than the freezing index indicates. Figure 8 shows variations in frost penetration between ground-temperature measuring installations and frost penetration as determined by excavation. These curves, compared with Fig. 9, mum frost depth in western Canada is due to greater time lag with the deeper frost line. Even when the mean daily temperature is well above freezing, heat continues to flow from the frost line to the lowest temperature region in the soil which may be several feet above the frost line. This extraction of heat will send the frost line deeper.

TABLE 1

Maximum Frost Penetration at Montreal Road Laboratories

Soil Type	Winter Studied	Maximum Frost Penetration—*ft*				
		Snow-Covered Soil			Uncovered Soil	
		Undisturbed Soil	Dense Soil	Loose Soil	Dense Soil	Loose Soil
Sand	1949–50	—	4.1	4.2	4.6	4.6
	1950–51	—	1.5	1.4	4.1	3.7
Clay	1949–50	1.8	3.0	3.0	3.4	3.15
	1950–51	0.45	0.6	0.9	2.5	2.45

Results at Road Laboratories

The first soil temperatures were recorded at the Montreal Road Laboratories of the Div. of Building Research in the winter of 1949–50. During the first winter trouble was experienced with instrumentation and there may be some inaccuracies in the records, but subsequent records are considered accurate. The average penetration of the 32 F isotherm for two winters is shown in Fig. 8 and Table 1.

As more records become available, a better interpretation of the results may be made. At present only a few general statements can be made:

1. Density of the soil appears to have little effect on frost penetration. This conclusion may not be valid when the actual density of the soil in the pits is checked.

2. Frost penetration averages about 1½ times as deep in sand as in clay, with, or without, snow cover. The effect of snow cover in this respect is not clear.

3. Disturbance of clay soils increases frost penetration to 1½ times the depth in undisturbed clay.

4. Frost penetration is considerably reduced by a blanket of undisturbed snow. The actual effect is uncertain because the snow blanket of 1949–50 was unusual, as shown in Fig. 10. During the winter of 1949–50, snow cover had little effect. In the following winter, 1950–51, removal of the snow tripled the frost penetration.

Factors Affecting Soil Temperature

A brief examination of the theory of heat flow (6) indicates some of the practical difficulties of a purely theoretical analysis of soil temperature variations. A simple equation expresses the rate of heat flow along a thermal gradient from warm to cold areas:

$$Q = KiAt$$

where Q = quantity of heat flowing, K = thermal conductivity, i = thermal gradient, A = area, and t = time. Thus the rate of heat flow over any given area is proportional to the thermal conductivity and to the thermal gradient.

The rate of change of temperature is expressed by a more complicated differential equation involving the thermal diffusivity of the soil. "Thermal diffusivity" is a term which expresses the ease with which temperature

changes can occur in the soil. If the soil freezes, latent heat is released, which adds to the complications.

These theoretical relations show that the rate of heat flow is proportional to the thermal conductivity, but the rate of temperature change, or the rate of frost penetration, is proportional to a more complex set of variables.

A detailed discussion of all the factors affecting soil temperature is not necessary, but some consideration of the variables is essential for an understanding of the problem. The variables may be divided into external factors

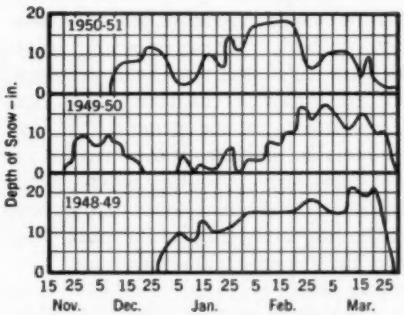


Fig. 10. Undisturbed Snow Depths at Montreal Road Laboratories

and intrinsic factors (*7*). The external factors are meteorological, such as air temperature, precipitation, sunshine, relative humidity, wind velocity, dew point, and barometric pressure. Intrinsic factors include topographic position, nature of surface and type of cover, moisture content of soil and its thermal conductivity, specific heat, organic content, specific gravity, radiation, absorption, texture and structure, evaporation, and concentration of salts in solution. This is a formidable list of variables, yet they are so interrelated that they compensate one another to a surprising degree. They illustrate, however, the difficulties in a theoretical calculation of frost penetration.

As present knowledge of the thermal properties of soils is limited, it is necessary to neglect many of the variables in both the theoretical and practical analyses. Of the external factors, only air temperature can be conveniently considered, but, fortunately, changes in the other external factors are generally reflected in the air temperature. Some of the intrinsic factors must be known for the theoretical analysis. A glance at some others will suffice to indicate their relative effect on soil temperatures.

Air temperature is, of course, the most important factor. The second most important variable is probably surface cover—for example, snow and vegetation reduce frost penetration and frost retreat. Pavement, on the other hand, increases penetration and accelerates retreat. Dark surface colors increase the absorption of solar energy —high temperature radiation—but do not have the same effect on the emission of heat from the soil—low temperature radiation. Radiation from the soil is governed largely by the soil's water content. All soils, when wet, tend to lose heat by radiation equally, as if they were black bodies. Many of the intrinsic factors are closely related to the texture and structure of the soil. About all that can be safely said of these variables is that frost penetration is generally greater in granular soils than in fine-grained cohesive soils.

Frost Penetration

High thermal conductivity aids frost penetration. Organic matter generally increases moisture content which, in turn, affects thermal conductivity and

volumetric heat capacity. In general, moisture appears to be a temperature modifier, reducing fluctuations and rapid penetration. Topographic position has an appreciable effect on frost penetration, northern exposures having greater frost penetration than southern exposures.

The freezing point of the soil has been a controversial subject for some time. It is thought that fine-grained soils freeze at a temperature slightly lower than 32 F. Dissolved salts in the soil moisture would contribute to the lowering of the freezing point. Many comparisons by the U.S. Corps of Engineers (4) of soil temperatures with actual frost penetration, measured by excavation, show that the average freezing temperature is close to 32 F.

Theoretical reasoning indicates that density and water content may have considerable effect on frost penetration in soil owing to the effect of these variables on the volumetric heat capacity and the thermal conductivity of the soil. As noted previously, the ease with which temperature changes can occur in soil is governed by the thermal diffusivity. Thermal diffusivity is equal to the thermal conductivity divided by the volumetric heat capacity. Thermal conductivity indicates the amount of heat flowing per degree Fahrenheit, and the volumetric heat capacity indicates the amount of heat required to raise or lower the temperature 1 F. As increases in density or moisture content cause increases in both thermal conductivity and volumetric heat capacity, these changes may have little effect on the thermal diffusivity of the soil.

Heat Flow

At the present time, the calculation of heat flow in the ground is based on general heat flow theory, using values of the coefficient of conductivity modified to compensate for the effect of moisture. These special values of the coefficient of conductivity are usually determined by placing a soil sample between a heated and a cooled plate, and measuring the heat input and temperature after steady-state conditions are achieved. It is generally recognized that under such a temperature gradient, the moisture begins to move from the hot side to the cold side. There is considerable discussion in the literature (8–10) of whether the water moves as liquid or by a process of evaporation, vapor migration, and condensation, or both. These opposing points of view have not yet been resolved, but are important in determining heat transmission in the ground. If any appreciable moisture movement as vapor takes place, resulting in the transmission of additional heat as latent heat in the migrating vapor, the usual heat flow theory may not be adequate.

The effect of vapor migration is to increase the heat flow, not only in the laboratory tests made to determine the coefficient of conductivity values, but also in the ground. The relative rates of vapor migration, however, may vary widely between the laboratory tests and the actual ground conditions, so that considerable errors may result. It is possible that future work will indicate such vapor migrations to be negligible in the soil. Until this is demonstrated, however, the possibility of error from this source must be admitted.

Transient methods capable of measuring the thermal properties of soils in place are now being developed (11, 12). These methods employ heated wires or spheres, and testing is carried out over a period of a few minutes. The migration of moisture occurring

during such a short time might be small but the rate of migration might be relatively high, and if the moisture movement occurs as water vapor, it might lead to fictitious results. It has been suggested that more heat arrives at a cooled coil in the ground—such as is used for a heat pump system of heating—than can be explained on the basis of the usual theory. The cause of this apparent discrepancy may well be the transmission of heat as latent heat in the migrating vapor.

Until the combined mechanisms of heat and moisture flow are more adequately understood, the application of heat flow theory alone in assessing the effects of density and moisture content must be made with reservations.

Effect of Air Temperature

As stated previously, air temperature is the most important factor affecting soil temperature and frost penetration. The common method of expressing the effect of winter air temperatures is the freezing index (13). The freezing index is the cumulative total of degree-days * below freezing point in any winter. To compute the index, the mean air temperature for each day is subtracted from 32 F to obtain the degree-days of frost, and the values obtained are added together for the whole winter. Values for mid-

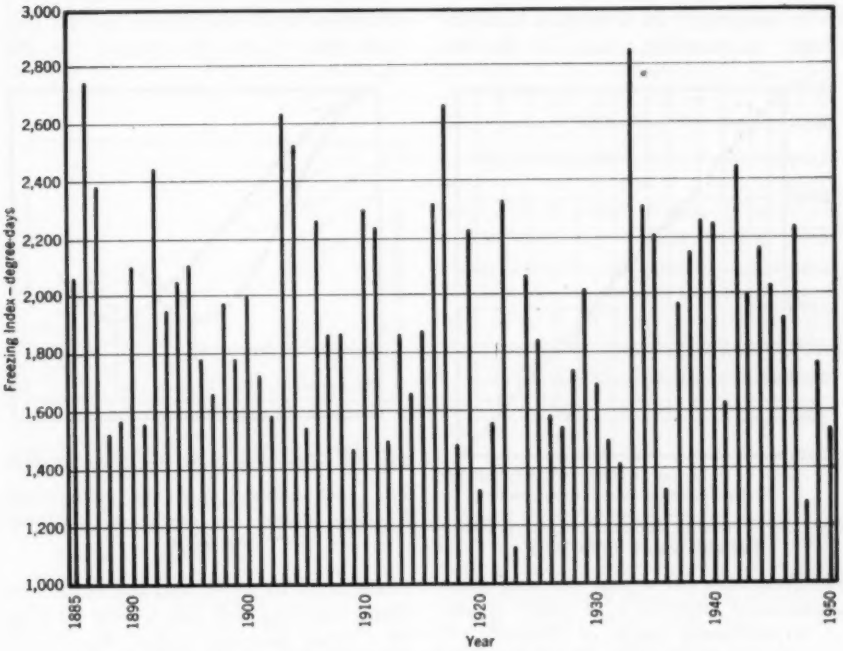


Fig. 11. Freezing Index Computations for the Years 1885–1950

Computations were made from records of the Experimental Farm at Ottawa.

* A unit representing 1° of declination from a given point (here 32 F) in the mean outdoor temperature for one day.

winter days with mean temperatures above freezing—that is, negative values of freezing index—are subtracted from the total. In the spring when the temperature trend is upward and temperatures are above freezing, the cumulation is discontinued.

Computation of the freezing index using mean daily temperatures is laborious if many years of records are to be analyzed. It is equally accurate to use the monthly means for December, January, February, and March if a correction is applied for the transitional months in the fall and spring. The following formula can then be used:

Freezing index = $30.3x$ + correction

in which 30.3 is the average number of days in December, January, February, and March, and x is the average of the monthly means for these four months subtracted from 32 F. The correction is the cumulative total of the degree-days of frost for the fall and spring months, and usually includes frost in late November and early April. The cumulation does not necessarily begin at first frost as its effect may be cancelled by subsequent higher temperatures. The freezing index for Ottawa air temperature records has been plotted for four years in Fig. 9.

The freezing index has also been computed from the records of the Experimental Farm at Ottawa for the years 1885 to 1950, and the results of these computations are shown in Fig. 11. The freezing index frequency, which was obtained from a statistical analysis of these records, is shown in Fig. 12. This figure shows that the 50 per cent frequency was 1,930 degree-days—that is, that half of the years studied had winters with a freezing index greater than 1,930 degree-days—and the 10 per cent frequency was 2,460 degree-days. The winter of 1947–48 had 2,234 degree-days of frost. The records indicate that a winter with this freezing index will occur every four or five years.

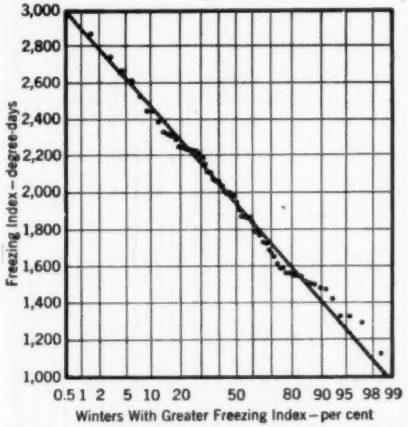


Fig. 12. Freezing Index Frequency Curve for the Years 1885–1950

The frequency curve was obtained from a statistical analysis of records of the experimental farm at Ottawa.

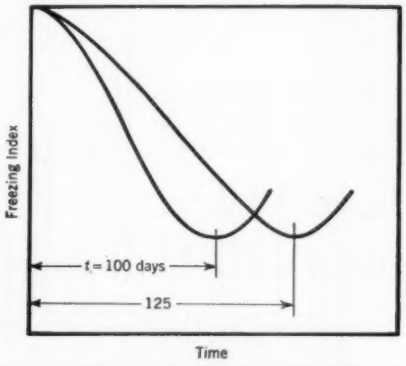


Fig. 13. Freezing Index for Two Winters

The two winters had the same total freezing index but were of different duration.

The classification of the severity of winters using the freezing index is probably oversimplified but no alternative has yet been suggested. For example, the winter of 1947–48 had some peculiarities which indicate that it was more severe than would be gathered from the freezing index. Figure 9 shows that it was a normal fall and an early spring, the maximum number of degree-days occurring in mid-March. Furthermore, it was a year of light snowfall—59 in. The 50-yr average for Ottawa is 88 in. The winter of

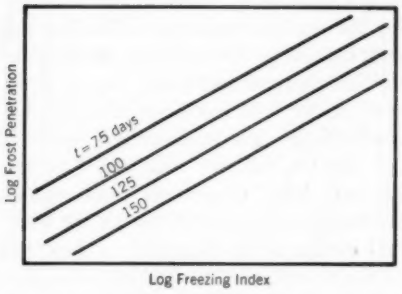


Fig. 14. Relation of Freezing Index to Frost Penetration

The time factor accounts for a variety of weather conditions throughout the country.

1942–43 had 2,770 degree-days of frost but the snowfall was 116 in. It is reasonable to believe that snowfall and the rate of accumulation of degree-days have some effect on winter severity. Figure 13 shows a qualitative plot of freezing index for two winters having the same total freezing index but of different duration. It is possible that the winter of 100 days duration would be more severe than the longer winter owing to the greater thermal gradient acting at the surface. If this reasoning is correct, it may be possible to draw a series of curves (Fig. 14) which would include a time factor to account for a variety of weather conditions throughout the country. The purpose of this family of curves is to show greater frost penetration for a steeper freezing index curve, and was a suggestion of N. B. Hutcheon of the University of Saskatchewan, a consultant to the Div. of Building Research.

The Ottawa winter of 1947–48, which had a steep freezing index curve and deep frost penetration, lends strength to this conviction. In addition, the rapid accumulation of degree-days during 1947–48 at Ottawa is similar to the normal winter weather in western Canada, and it seems unlikely that only one curve of frost penetration against freezing index would accurately include the wide variety of weather experienced in Canada. Many field records of frost penetration will be required to complete this analysis, and it is hoped that a collection of these will begin during the next winter season.

Effect of Snow Cover

Snow cover has considerable effect on soil temperatures and frost penetration. Some investigators of winter soil temperatures have noted its effect in the undisturbed state, and a few have compared the effect of undisturbed and compacted snow. All have agreed that snow cover will appreciably reduce frost penetration. The thermal conductivity of snow is a function of its density. Independent investigators have agreed, within fairly narrow limits, in their measurements of conductivity, as shown in Fig. 15, which is based upon a study of the properties of snow and ice (14).

Snow depths and density have been measured by the Div. of Building Re-

TABLE 2

*Undisturbed Snow Depths and Densities**

Date of Observation	Elevation of Samples *in.*	Specific Gravity of Snow	Snow Depth *in.*	Average *k*† *Btu/ft/°F/hr*
12/1/49	4	0.21	7	0.09
12/15/49	2	0.31	3	0.16
2/16/50	4½	0.22	10	0.10
	7½	0.24		
3/8/50	2	0.28	12	0.12
	5	0.25		
	9	0.24		
3/16/50	2	0.36	15	0.14
	6	0.33		
	12	0.14		
1/15/51	2	0.22	10	0.08
	7	0.16	10	
1/30/51	2	0.25	11	0.08
	4	0.20		
	9	0.12		
	11	0.19		
2/15/51	3	0.28		0.12
	7	0.22		
	12	0.24	17	
	15	0.30		

* The observations were made at the Montreal Road Laboratories.
† Coefficient of conductivity.

search since 1948. These data are shown in Fig. 9 and Table 2, and from them the values of thermal conductivity for undisturbed snow can be estimated.

The warming effect of snow cover is clearly shown in Fig. 16, which shows that maximum frost penetration during 1950–51 in sand with no snow cover was 46 in., and with snow cover was 18 in.; in clay with no snow cover it was 29 in., and with snow cover was 11 in. In undisturbed clay with snow cover, the penetration was only 6 in. Part of the difference between the mean annual air temperature and the almost constant soil temperature at 15 or 20 ft below the surface can be attributed to the insulating effect of snow.

Heat flows along the thermal gradient from warm to cold regions. Snow acts as an insulating blanket which reduces the penetration of frost. As frost penetration is dependent on more than simple relations of thermal conductivity, the degree of protection offered by snow cover is not a simple function of its depth and density. It is interesting to note, however, the relative values of thermal conductivity for the various materials affecting soil temperatures—for example, in terms of British thermal units per degree Fahrenheit per foot per hour, the thermal conductivity for undisturbed snow is 0.1; for ice, 1.3; for concrete, 0.5; and for soil, 0.8. Obviously these values are rough approximations, as the thermal conductivity is usually a function of such variables as density, moisture content, and mineral type and also depends on whether or not the soil is frozen. Nevertheless, the numerical values give an impression of the protection offered by snow, ice, concrete, and soil. Of the four thermal conductivity values given, the most significant value is that for ice, which shows that the protection against heat loss offered by pure ice is less than that of soil.

It may be more illustrative to compare, in a general way, the values for thermal diffusivity of soil, snow, and ice. On the average, the thermal diffusivity of ice is about 3 times as great as that of undisturbed, but not fresh, snow, and the thermal diffusivity of soil ranges from 2 to 3 times that of snow. These values indicate that, for a certain thermal gradient, ice and soil will change temperature at about the

same rate, and that undisturbed snow will resist temperature change as much as 1½ or 2 times its depth of soil.

The protection against frost provided by partially disturbed snow was revealed by a study of field records of excavations in Ottawa of actual frost penetration under snow-free streets and the adjacent snow-covered boulevard. These records show that frost penetration is reduced by 1.7 to 2.7 ft for each foot of snow cover. The probability average of the records is approximately 2 ft.

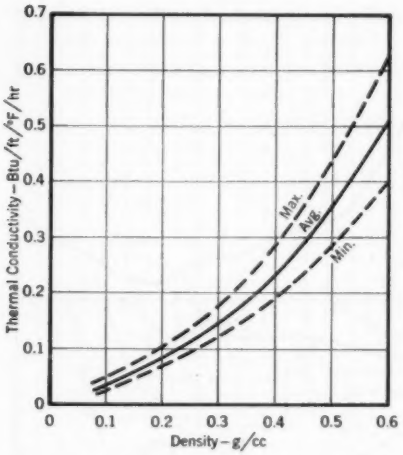


Fig. 15. Thermal Conductivity of Snow

Conclusions

An understanding of soil temperature variations in soils of different types, both disturbed and undisturbed, is a basic requirement for a full appreciation of the problem of freezing water mains. Although knowledge of all aspects of soil variations is still far from complete, a steadily increasing interest is being shown. As more field observations are published, and details of laboratory investigations are reported, the unknowns in the problem will gradually be reduced.

Theoretical equations for the computation of frost depth have been developed by several workers, but comparisons of actual and theoretically computed frost depths indicate that the theoretical approach is not yet free from error. An empirical design curve, developed by the U.S. Corps of Engineers (3–5), appears to be, at present, the best aid in frost prediction, and its application under Ottawa conditions is illustrated in this paper.

In spite of the uncertainties still awaiting solution, a careful study of the results obtained from the experimental work conducted at Ottawa suggests certain general conclusions:

1. The significant difference between the depth of frost penetration in disturbed and undisturbed soil suggests that if soil can be backfilled to something approaching its original undisturbed condition, some reduction in the depth of pipe trenches might be possible. This possibility is being studied.

2. It is clear that water pipes may safely be placed at less depth in clay soils than in sandy soils.

3. The design curve shown in Fig. 6 shows a reasonable relation between frost penetration and freezing index for most of the soils studied, but its use must be tempered with caution until more corroborative evidence is available for Canadian conditions.

4. If 500 or more degree-days occur before the end of December in Ottawa, some consideration should be given to restricted snow plowing in areas where water pipes are vulnerable.

5. The authors suggest a modification of the freezing index concept to take account of the rate at which freezing weather occurs. An outline of this modification has been given; the au-

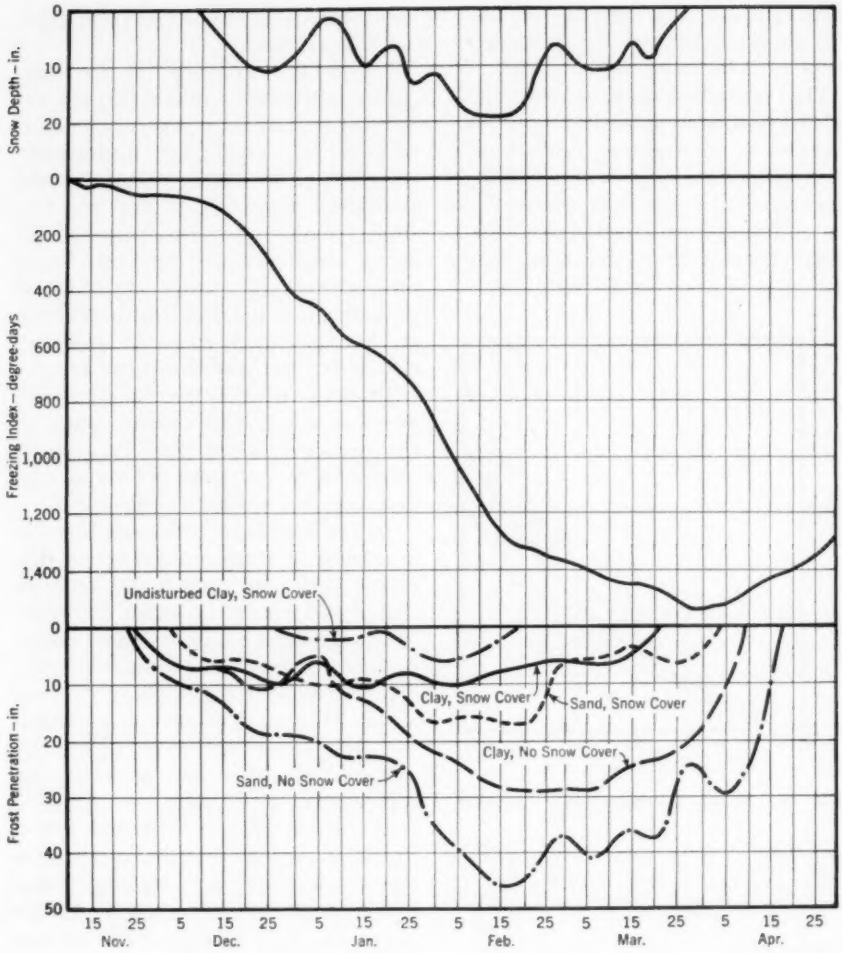


Fig. 16. Effect of Snow Cover on Frost Penetration

Measurements were made in the Ottawa test pits in 1950–51.

thors hope to publish design curves when sufficient evidence has been accumulated.

6. The extent of the effect of snow cover in its various states is still in doubt. It is now known, however, that an undisturbed continuous snow cover will reduce frost penetration in the Ottawa climate by an amount equal to or greater than its own thickness.

7. Traffic-packed snow will reduce frost penetration somewhat more than pure ice, depending on the density of the snow. This points to the desirability of conserving snow cover whenever possible in water works practice.

Only by the steady and patient accumulation of factual evidence will it be possible to advance in this study with confidence. A number of research organizations are conducting investigations under controlled conditions and in laboratories. Additional information is required, however, from actual field experience.

Acknowledgments

The information presented in this paper represents a careful selection from the results of a large amount of patient observation. The authors are therefore indebted to many associates for assistance in the work and, in particular, to their own colleagues in the Soil Mechanics Section of the Div. of Building Research. They have benefited by many helpful discussions with N. B. Hutcheon, Prof. of Mech. Eng., University of Saskatchewan, and consultant to the division. They wish to pay special tribute to the cooperation extended to the division and to them, personally, by all the officials of Ottawa who have been concerned with the cooperative program and, in particular, to W. E. MacDonald, Water Works Commissioner, and members of his staff; Cecil Wight, Director of Planning; and J. H. Irvine, Commissioner of Works, and members of his staff. The interest shown by these men has been a continuing encouragement to the division. Permission to publish the data obtained in cooperation with the city of Ottawa is gratefully acknowledged.

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A Study of the Taste of Fluoridated Water

By Gerald J. Cox and Jessica W. Nathans

A paper presented on June 20, 1952, at the Pennsylvania Section Meeting, Erie, Pa., by Gerald J. Cox, Prof. of Dental Research, and Jessica W. Nathans, Research Asst., both of the Research Dept., School of Dentistry, Univ. of Pittsburgh, Pittsburgh, Pa.

A FEAR sometimes expressed in opposition to fluoridation of water for the prevention of dental caries is that an objectionable taste will result. Those having experience in fluoridation quickly deny that any taste is contributed by current practices of adding fluorides of any kind to water. The authors have sought to determine the probability that anyone could taste sodium fluoride at the levels (approximately 1 ppm) added in fluoridation, and to provide positive evidence of human ability to taste fluorides in water.

The taste panel consisted of 187 third- and fourth-year dental students, all males. The criterion of positive tasting was the ability to distinguish a given solution from distilled water by any method of tasting procedure adopted by the students. By such a laissez-faire method it was possible to learn from the students, better procedures of tasting. The methods described are those that were adopted toward the end of the explorations.

Experimental

The dilution series of sodium fluoride in distilled water is given in Table 1. It is based on an arbitrary choice of eight geometric increments from 10 to 100 ppm fluoride. The incremental ratio is 1.33352, the antilogarithm of $\frac{1}{8}$. The solutions and distilled water were made available in a random array of eleven open glass cups. For each test either five or six of the cups contained fluoride solution of a single concentration. The subject was given an opportunity to acquaint himself with the taste of the concentration of fluoride under test and of the next higher concentration in the series and to compare them with distilled water. Thereafter he compared the tastes of the series with distilled water. The comparison was made quickly, as memory proved to be short for the slight difference in taste.

Actual tasting was done from varied glass tumblers. The subjects gradually developed from an initial sipping technique to the practice of using several mouthfuls for each comparison. The total volume of expectorated liquid for the series of eleven frequently amounted to approximately 2 liters. This practice developed late in the study and probably accounts for the low thresholds attained by some of the subjects.

In testing with an array of eleven containers, a score of two or fewer errors was judged a success. (The probability of such an occurrence by chance is 0.027.) If three or four errors occurred, the subject was asked to repeat the tasting. If, in the repeat test, three or fewer errors were made, it was judged successful tasting; if more, a failure. More than four errors in the initial test was judged a failure.

On the basis of preliminary studies, the testing was begun at 133 ppm fluorine for all members of the panel. Those who failed to distinguish this solution from distilled water were offered higher concentrations until they finally succeeded. Those successful at 133 ppm fluorine were tested at 100 ppm and the lower levels. These subjects entered into a spirit of competition differing from those who had been declared "failures" and the anticipated linearity of findings was upset. The development of the mouth flushing technique of tasting began at this stage and accounted, in part, for greater than anticipated success.

TABLE 1

Taste Distinction Between Distilled Water and Sodium Fluoride Solutions

Fluorine Conc.*		Students Who Succeeded but Failed at Lower Levels—*No.*	Students Who Succeeded at This and All Higher Levels	
ppm	*millimolar*		*No.*	*per cent*
750	39	2	187	100.0
562	29	1	185	98.9
422	22	5	184	98.4
316	17	13	179	95.7
237	13	18	166	88.8
178	9.5	35	148	79.1
133	6.8	23	113	60.4
100	5.3	11	90	48.1
75	3.9	11	79	42.3
56	2.9	4	68	36.4
42	2.2	11	64	34.2
32	1.7	15	53	28.3
24	1.3	14	38	20.3
18	0.95	6	24	12.8
13	0.68	10	18	9.6
10	0.53	4	8	4.3
7.5	0.39	2	4	2.1
5.6	0.29	1	2	1.1
4.2	0.22	0	1	0.5
3.2	0.17	0	1	0.5
2.4	0.13	1	1	0.5
		187		

* The most successful taster failed repeatedly to detect fluorine at a concentration of 1.8 ppm fluorine. The common fluoridation level for public water supplies is approximately 1 ppm.

As the end of the academic year 1951–52 approached, it became necessary to speed up the procedure in order to complete the testing of all subjects. The authors tried having a subject taste through three arrays in immediate sequence, and, surprisingly, the subjects became more successful instead of showing evidence of fatigue. This enhancement of the ability to distinguish the fluoride solutions may have resulted from: [1] greater removal of saliva from the mouth; [2] removal of mucus deposits; [3] extraction of salts from oral tissues, thus rendering them more sensitive to the waterborne salt; or [4] a combination of these causes.

Results

The results of the complete study are given in Table 1. Without attempting to smooth or correct the data for the improvement of the methods of tasting, the authors have derived, by the method of probits, a probability of somewhat less than 0.001 that anyone can detect sodium fluoride in distilled water at 1 ppm fluorine by the most favorable tasting procedure. It is the authors' opinion, and the consensus of the tasters, that no one could detect sodium fluoride in water at 1 ppm fluorine in a casual test.

The studies on the third- and fourth-year students amounted to 1,107 tests of eleven unknowns or a total of 12,177 single comparisons with distilled water.

The taste of sodium fluoride when placed dry on the tongue is salty, somewhat weaker than sodium chloride, probably because of lower solubility. The threshold with which these tests dealt, however, was not the threshold

of the salt taste but a much lower threshold observed by Renqvist (1) and by Richter and MacLean (2). The latter, in particular, described a variety of taste sensations reported by subjects tasting sodium chloride at what they termed "subthreshold" levels. The authors' subjects reported the taste sensations given in Table 2. As Richter and MacLean observed with sodium chloride, a number of the subjects reported that the fluoride solutions tasted sweet. These findings

TABLE 2

*Frequency of Taste Sensations From Sodium Fluoride Solutions**

Sensation	Success at 2.4–100 ppm F	Success at 133–750 ppm F
More palatable	17	8
Sweet	30	14
Sour	2	1
Bitter	5	17
Salt	14	31
Alkaline	3	9
Miscellaneous	19	17
Total	90	97

* These data, which were obtained from the entire group, have been classified according to the most and the least successful tasters. The most successful tasters frequently reported sensations of more palatable and sweet, the least successful bitter and salt. Only 5 times out of 10,000 could this distribution occur by chance as indicated by the χ^2 value of 25.3, with 6 degrees of freedom.

indicate that if anyone does detect the presence of fluoride in water by means of taste, it will be because of an improvement in flavor.

Additional Tests

Eight of the most successful tasters were tested for ability to recognize the presence of NaCl, KCl, KF, NaSCN, NH_4SCN, and sodium and potassium formates in distilled water in a concentration equivalent to 18 ppm fluorine. With the exception of a disagreeable "sulfur" taste from NH_4SCN, results of taste sensations similar to the tasting of sodium fluoride solutions were reported by these subjects. It was observed, however, that significantly more errors were made in the tasting of the potassium salts. This finding has led the authors to believe that it is the sodium ion that is mainly effective in contributing to the taste sensations of this group of eight subjects. Furthermore, because of these findings with the various salts, the authors propose for the subthreshold levels observed by Renqvist (1) and Richter and MacLean (2) the term "ionic effect" as a distinct sensation from the classical taste sensations of salt, sour, sweet, and bitter. There is no indication of what oral structures are involved in the detection of the ionic effect.

Conclusion

1. A solution of sodium fluoride at a concentration as low as 2.4 ppm fluoride can be distinguished by taste from distilled water through the effect of the ions of this salt. The authors call the mechanism of detection the ionic effect.

2. The probability has been computed that not one in a thousand persons can detect sodium fluoride in distilled water by the ionic effect at 1 ppm fluorine.

3. These studies at low concentrations of salts indicate that the palatability of water is due to subthreshold sensations of salts or to the ionic effect.

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Natural and Applied Fluoridation Census: Supplemental Report

Task Group E5–10

A supplemental report by Task Group E5–10—Committee on Fluoridation Materials and Methods. Both the initial report, published in the June 1952 Journal, and the supplementary material were presented on May 7, 1952, at the Annual Conference, Kansas City, Mo., by O. J. Muegge, Chairman; State San. Engr., Bureau of San. Eng., Madison, Wis.

THE partial report by Task Group E5–10—Committee on Fluoridation Materials and Methods, published in the June 1952 JOURNAL, included a list of fluoridation plant installations in operation in the United States and Canada on December 31, 1951, a cumulative summary by years of the number of installations and size of population served, the chemicals used and the methods of application, and the natural fluoride content of public water supplies. This supplemental report comprises the balance of the committee report.

Installation Sequence

The first 25 communal water works systems providing for dental caries control through fluoridation plant installations, in order of installation, are given in Table 1. Three state schools must also be included in the recording of early fluoridation plant installations —the Southbury State Training School of Connecticut in April 1945 and the Belcherton and Wrentham State Schools of Massachusetts in December 1946.

Fluoridation Chemicals

Four chemicals are being used at present in water supply fluoridation. Sodium fluosilicate continues to be the cheapest chemical; the cost per million gallons is approximately one-half that of sodium fluoride or hydrofluoric acid and approximately one-third that of hydrofluosilicic acid. Because of its economy, most of the newer installations are using sodium fluosilicate and a number of older fluoridation plants are changing over from sodium fluoride. Because data on the effectiveness of sodium fluosilicate in controlling dental caries are not yet available, a few states discourage the use of this source of fluoride. Supply shortages in past years have also tended to discourage its use.

Hydrofluosilicic acid, in spite of its greater cost, is also being favored for use at many new plants. Simplicity of operation, high concentration of fluoride, and avoidance of dust contribute to its popularity. The high concentration of fluoride in this chemical requires most foolproof feed equipment to avoid overdosage or back-siphonage. Dilution of the acid with water having a hardness greater than 30 ppm has resulted in some problems because of a precipitation or jelling reaction. Corrosion by dilute acid is a serious problem, and consequently the use of dilute acid is not advocated by the committee.

Use of hydrofluoric acid is discouraged by most state health departments because of its corrosiveness and the hazard to operating personnel. Use of this acid is limited to the initial installation at Madison, Wis. A recent dental survey in that city has indicated dental caries control comparable to that obtained in other communities using sodium fluoride.

The use of ammonium fluosilicate is being advocated by one supplier. The effectiveness of this chemical is being studied by the U.S. Public Health Service. The cost would be comparable with that of sodium fluoride on the basis of available fluoride. The solubility is 19 per cent. Ammonium fluosilicate is reported to be less subject to caking than sodium fluosilicate. The effect of the ammonia in this compound on chlorination processes should be considered in comparing it with other fluoride-bearing compounds. Except for hydrofluosilicic acid in some locations, no difficulty is being experienced at this time in obtaining the fluoridation chemicals.

Fluoridation Equipment

Information on the type of dry-feed unit was supplied for only 73 of the 135 plants using such equipment. Of the 73 plants, 54 have a volumetric type of dry-feed unit and 19 have a gravimetric type. The gravimetric dry-feed units are generally used on the larger installations. Eight of the 109 sodium fluoride, solution-feed units are of the saturator type wherein a charge of chemical is placed in a tank through which the feedwater passes. Sufficient contact time is provided to produce a saturated solution. This procedure is suitable because of the very uniform solubility of sodium fluoride over the temperature range encountered in water works practice.

Two installations using sodium fluosilicate applied the chemical as a slurry with solution-feed equipment. Actually, because of the low solubility of the fluosilicate, some of the larger dry-feed units are also applying this chemical as a slurry or suspension.

TABLE 1

First Fluoridation Plant Installations

City	*Date Installed*
Grand Rapids, Mich.	1/45
Newburgh, N.Y.	5/45
Brantford, Ont.	6/45
Midland, Mich.	1/46
Sheboygan, Wis.	2/46
Marshall, Tex.	5/46
Ottawa, Kan.	9/46
Evanston, Ill.	2/47
Lewiston, Idaho	6/47
Elkhorn, Wis.	4/48
Madison, Wis.	6/48
Janesville, Wis.	2/49
Beloit, Wis.	4/49
Charlotte, N.C.	4/49
Mukwonago, Wis.	5/49
Baraboo, Wis.	5/49
Antigo, Wis.	6/49
Algonac, Mich.	9/49
Stoughton, Wis.	9/49
Ashland, Wis.	10/49
Gainesville, Fla.	10/49
Edgar, Wis.	11/49
Richland Center, Wis.	12/49
Ludington, Mich.	12/49
Fort Atkinson, Wis.	12/49

Reported costs of installation ranged from $400 to $1500 for solution-feed and from $500 to $12,000 for dry-feed equipment. Further analysis of cost data is not warranted because of lack of detail on the individual installations.

Plant Personnel Protection

Nearly all states require the use of respirators and protective clothing by employees handling the fluoride chemi-

cals. An examination of the regulations which were forwarded with the returned questionnaires by 32 state health departments indicates that 11 of the 32 states require dust collection or exhaust equipment with all dry-feed installations. One other state requires such equipment when the dry-feed unit contains a vibrator. Several other states recommend dust collection equipment. Of the 135 dry-feed installations in operation, 51 have installed dust collection equipment. The committee feels that dust collection equipment should be provided for all large installations and also for small installations if the liberation of excessive dust occurs.

Studies conducted by the Industrial Hygiene Div. of the Wisconsin State Board of Health indicate that the exposure of employees to fluoride concentrations in the air is well below the allowable exposure of 2.5 mg per cu m continuously over an eight-hour day, five-day week. The fluoride concentrations observed at a number of installations are given in Table 2.

The handling of the bags to and from storage is another source of dust, particularly because the bag loading valve is not tightly sealed. Small puffs of dust may be liberated while the bags are being handled. Because of the difficulty of installing dust collection equipment at truck unloading and storage points and the probable ineffectiveness of such equipment if installed, handling of the bags should be minimized by using movable storage racks. The wearing of dust respirators is considered essential and the best protection for the personnel handling the bags or chemicals, as respirators protect against direct exposure to puffs of dust. Dry sweeping of floors or dry dusting of equipment should be avoided.

TABLE 2

Fluoride Concentrations

Unit Type	Dust Collector	Fluoride—mg/cu m				
		Before Loading	Breathing Zone During Loading	11–12-min Period After Loading	Next 10-min Period	30 min After Loading
NaF solution	No	0.78	41.00	3.70	1.60	—
NaF dry feed	Yes	0.025	8.89*	—	—	0.119
Na_2SiF_6 dry	No	0.08	3.50	0.71	0.14	—
Na_2SiF_6 dry	No	0.08	0.46	0.06	0.08	—
Na_2SiF_6 dry	Yes	0.08	9.20*	1.40	0.36	—

* Hoppers filled by pouring directly from bulk containers. In other plants, chemical transferred in small containers from bulk drums to feed hopper or solution tank.

Fluoridation Plant Controls

The controls over water supply fluoridation by the state health departments are relatively uniform. Of 45 states responding to specific inquiry, 43 require approval of plans covering equipment and installation, 16 require supervision of plant operation by a licensed or registered operator, 39 require daily tests of fluoride residuals, 41 require periodic check analysis by

state or county health department laboratories, and 39 require reports on operation at monthly or weekly intervals.

A review of regulations or approval policies of 30 states indicates that before approving installation of fluoridation equipment, 16 states require the adoption of an ordinance or resolution by the governing body of the municipality to be served, 18 require prior approval of local and medical groups, and 18 require approval in writing by the local health department.

In view of past court decisions on similar matters, and the recent decision of the Superior Court of San Diego on fluoridation in which it was held that the programs were a valid exercise of "police power," *it would appear that every water works utility should have authorization or direction to apply fluorides by means of a resolution or ordinance of the governing body of the municipality served by the water system.* This procedure is in complete accord with the policy of the American Water Works Assn.

Program Approval

The fluoridation of communal water supplies is now generally approved or permitted by all state health departments. Of 45 states reporting, all permit such a dental caries control program. In these same states the program has been endorsed by 41 state dental and 33 state medical associations. In 1951, approval of fluoridation was given by the American Medical Assn. and the National Research Council.

Correction

In the "Tentative Standard Specifications for Gate Valves for Ordinary Water Works Service," AWWA C500, which appeared in the September 1952 JOURNAL, the italicized phrase below was omitted on page 864, Section 9.2.3. The last sentence in this section should be amended to read:

> At the manufacturer's option (*subject to purchaser's approval*), monel made to Navy Specification 46MI may be used for wedging surfaces instead of Grade I bronze.

Water Fluoridation and Dental Research

By Horace R. Frye and Iden N. Hill

A paper presented on March 26, 1952, at the Illinois Section Meeting, Chicago, by Horace R. Frye, Supt., Water Dept., Evanston, Ill., and Iden N. Hill, Dentist, Zoller Memorial Dental Clinic, University of Chicago, Chicago.

THE Evanston, Ill., dental caries study, to determine whether or not the addition of a minute amount of fluorine to the communal water supply would reduce the incidence of dental caries in children, was started in 1946. Several papers covering various phases of the project have been published in the *Journal of Dental Research,* but as yet no direct report has been made to the water works profession. It is for this reason that the findings of the Evanston dental caries study, as they pertain to the water works group, are summarized in this paper.

After comparing the high dental caries rate prevalent in Evanston, Oak Park, and Waukegan—all of which use water from fluorine-free Lake Michigan—with the much lower rates for cities using water containing 1–2 ppm fluorine, Winston H. Tucker, commissioner of health of Evanston, late in 1944 called a meeting of local physicians and dentists to discuss the problem. Interest grew in the possibility of adding a fluoride to the drinking water, and a study of the effect of the treatment was proposed.

The details of the steps taken to get the study underway will not be given, but it is important to note that all interested groups were in agreement and full cooperation was promised. These groups included the local dental and medical societies, the public and parochial school boards, the city council, the Illinois Dept. of Public Health, and the officials and school boards of the village of Skokie, which is supplied with Evanston water. The Walter G. Zoller Memorial Dental Clinic of the University of Chicago, under the direction of J. R. Blayney, agreed to participate in the study.

It was decided to see what effect the addition of a minute amount of sodium fluoride to the communal water supply would have on the incidence of dental caries in Evanston and Skokie children. It was carefully explained to the Evanston citizens that nothing could be promised regarding the ultimate value of the program in the control of tooth decay; that if such a program were to be undertaken it must be in the nature of an exhaustive study; and that it would be several years before data would be available to indicate what trend might be expected. The study was begun in 1946 after these preliminary explanations had been given.

Dental Procedures

The study began with the examination of all school children in the 6-, 7-, 8-, 12-, 13-, and 14-year age groups, in order to establish a base line before adding the sodium fluoride to the water. In addition, inasmuch as all such

studies should have a control city, the dental and medical professions, the health authorities, and the school boards of Oak Park offered to have their city serve in this capacity.

The method by which sodium fluoride acts to reduce the incidence of dental caries is not definitely known. It was therefore advisable to plan the study with a view to obtaining as much information as possible. It was decided that the school children in the above-mentioned age groups would provide the best opportunity to assess the caries experience in the deciduous teeth and to study the initial caries attack rates of permanent teeth. These age groups provide the opportunity of appraising the rate at which caries progresses in the various age levels during different time intervals following the introduction of sodium fluoride into the water.

The study was planned to continue for a fifteen-year period. When at least one group reaches fourteen years of age (maximum in the study), the children will have been exposed to fluoridated water throughout their entire life—prenatal and postnatal (1).

Dental examinations including six anterior radiographs and two to four posterior bite wing films are given to all children. All examinations are performed in the schools with adequate dental equipment and proper lighting. This schedule is arranged to allow ample time for a thorough examination. The same dentists interpret the caries, fillings, conditions of investing tissues, and cases considered immune. The opinion of at least two dentists is obtained before the final number of caries, fillings, and immune cases is determined. The findings of dental significance are transferred to coded sheets and this coded material is segregated and classified chronologically at the Bureau of Vital Statistics, Dept. of Health, Springfield, Ill. All data have been evaluated by approved statistical methods.

Laboratory Methods

It is known that fluorine compounds are present in numerous foods. Therefore, it is advisable to know approximately how much fluoride is being ingested in the diets of Evanston residents. A chemist was placed on the staff to determine the fluorine in foods purchased locally. Chemical analyses were also undertaken to find the amount of fluorine occurring in teeth and bones. In addition, urine samples were obtained and analyzed for fluorine over a period of two years. Fluorine determinations on water samples taken from the plant and the distribution system are made daily. The Scott modification of the Sanchis method is used in determining the fluorine present in the daily water analysis (2). All other materials are analyzed by the method of Willard and Winter (3), as modified by the Assn. of Official Agricultural Chemists (4).

TABLE 1

*People in 32 States Having Access to Water Containing Natural Fluorides in 1946**

No. of People Having Access	Fluorine *ppm*
2,658,211	0.5–0.8
2,195,115	0.9–2.0
626,177	2.1–3.0
127,243	3.1–5.0
40,151	5.1–higher
5,646,897	

* 6,038 water analyses were submitted.

Plant Procedures

Sodium fluoride was chosen to supply the fluoride ion because of its availability at the time the study was

started, its high solubility, and its reasonable cost. The increased production of sodium silicofluoride in the past two years has given the water works operator a suitable fluoride compound at a lower cost, and many of the larger cities are using this chemical. There is no reason to believe that the fluoride ion would be less effective in the reduction of tooth decay when supplied by sodium silicofluoride rather than sodium fluoride, but, as this assumption has not been verified by comparative studies, it was decided that Evanston should continue to use sodium fluoride for the remainder of the fifteen-year period.

TABLE 2

DMF Caries Rate of Permanent Teeth*

Town	Fluorine *ppm*	No. of Examinations	Age		
			12	13	14
			No. of Caries per 100 Chidren		
Aurora† (1945–46) (entire life)	1.2	1235	295.	309.	364.
Evanston† (1941)	0.0	673	563.	676.	793.
Oak Park† (1941)	0.0	329	583.	696.	907.
Evanston (1946)	0.0	1226	707.51	946.17	1133.33
Oak Park (1947)	0.0	1020	747.51	970.00	1194.64
Evanston (1949)	1.0‡	1251	625.49	785.89	1073.31

* Decayed, missing, and filled teeth per 100 children.
† Data collected by Dean and associates (6, 7).
‡ The examinations were made after the Evanston residents had been given fluorine-treated water for 23–34 months.

The facilities for feeding the chemical at Evanston are not unusual, but are outlined for the use of those who may be contemplating the addition of a fluoride. A gravimetric feeder * is installed on the main floor of the chemical building. It is loaded through a 12-in. steel pipe which extends to the chemical room floor directly above the machine. A special dumping hopper which allows a barrel or drum to be inverted inside it was constructed over this pipe. When the door is closed, no dust can escape into the room. A bag type dust filter inside the canopy removes all dust and insures a high degree of safety for the operator. As an added precaution, the operators are required to wear dust masks while handling the chemical. Shipments of sodium fluoride are taken off the trucks and piled on dollies which are taken to the second floor chemical room by elevator. The bags or drums are stored on the dollies and are not handled until they are dumped into the machine. This system of chemical handling has proved very satisfactory both in eliminating the dust hazard and in minimizing the work.

The chemical hopper, which is also enclosed in a dust-tight compartment, is mounted on scales. The feed mechanism gradually throws the scale beam off balance, thus causing chemical to be discharged into the dissolving chamber at the desired rate. Any over- or

* A product of the Omega Machine Co., Providence, R.I., was used.

underfeeding causes an alarm to sound, warning the operator at once. A recording chart connected to the scale beam keeps a permanent record of the rate of feed. The dissolving chamber is equipped with water jets which keep the solution circulating, and, inasmuch as the discharge is at the top, no undissolved chemical can reach the clear wells. The solution travels by gravity from the machine to the point of application through a 2-in. rubber hose. The solubility of the sodium fluoride, the safety features built into the machine, and the fact that the solution is applied at a point which requires circulation through several large clear wells before reaching the high-lift pumps make it impossible to apply toxic dosages of sodium fluoride to the distribution system.

Dental Findings

The questionnaires used in the Evanston dental caries study occasionally revealed that some of the children formerly lived in areas in which fluorine was a natural constituent of the communal water. The authors thought it would be helpful to know the approximate location of areas in which fluorine is prevalent in drinking water supplies, and in what strength, and also the number of people in this country who are drinking or who have access to a communal water supply in which fluorine is a natural constituent.

To obtain this material, the chief sanitary engineer of each state and the District of Columbia was requested to report the fluorine concentration of the communal water supply in each city, town, and village in his state. The cooperation of these engineers was extremely gratifying. The information received showed that fluorides occur as a natural constituent of some of the communal water supplies in 32 states, but that three areas in particular—[1] an area comprising Indiana, Ohio, and Illinois, [2] the South Dakota area, and [3] the state of Texas—have a heavier concentration of fluorides in their communal water supplies than any other sections of the country (5). It was also determined that there are municipalities having a high fluorine content in nine states; the greatest number is in Texas, and the next greatest in South Dakota. When this material was compiled in 1946, there were at least 5,646,897 people in the United States who had access to a communal water supply containing 0.5 ppm fluorine or more (Table 1). This number of people is approximately 4.3 per cent of the entire population of the United States, and is 7.24 per cent of the total population (78,534,458) of these 32 states. There are 2,195,115 people in the fluorine concentration bracket from 0.9 to 2.0 ppm, and 626,177 people in the 2.1–3-ppm bracket. In a still higher concentration range of 3.1–5.0 ppm, there are 127,243 people. Municipalities having an unusually high fluorine content—5.1 ppm

TABLE 3

DMF Rates in Permanent Teeth After Fluoride in Water 23–34 Months*

Year	No. Examined	Age		
		12	13	14
		No. of Caries per 100 Children		
1946	1,701	763.16	1,009.59	1,165.88
1949	1,769	681.99	857.02	1,086.84
Reduction—*per cent*	——	11.16	15.11	6.78

* Decayed, missing, and filled teeth per 100 children. Tests conducted on Evanston children.

and higher—number only 25, and the number of people (40,151) exposed to this high level of fluorine is not great.

In 1945 Dean and associates (6) conducted a dental survey in Aurora, Ill. Aurora at that time had a communal water supply containing fluorine as a natural constituent in a strength of 1.2 ppm. In 1941 Dean also examined the teeth of children in Evanston and Oak Park (7) neither of which had fluorine in its communal water supply. The authors compared Dean's findings with the findings of the Evanston caries rate after the children had been exposed to an artificially fluoridated water for a period of 23 to 34 months (Table 2).

TABLE 4

*Fluorine Content of Soup**

Soup	Fluorine ppm	Cannery Location
Brand A		
Beef Noodle	1.00	Chicago
Ox Tail	0.85	Chicago
Chicken Noodle	2.80	Chicago
Scotch Broth	0.40	Chicago
Chicken Gumbo	1.00	Chicago
Pepper Pot	0.80	Chicago
Brand B		
Vegetable	1.10	Medina, N. Y. (?)
Chicken Noodle	1.60	Pittsburgh, Pa.
Beef Noodle	0.98	Pittsburgh, Pa.
Gumbo Creole	0.65	Medina, N. Y.
Pepper Pot	0.80	Chicago

* The data were taken from "Determination of Fluorine in Foods, Bones, and Teeth" (10).

As Dean and his associates examined only white public school children in Aurora and Oak Park at that time, the authors have compared only the white public school children from Evanston. Radiographic examinations were made in the Evanston study, and some difference in the rates of incidence normally would be expected. The incidence or rate of dental decay among children in Aurora, however, is much lower than the rate of the Evanston school children. The 1946 Evanston and the 1947 Oak Park rates are quite similar; however, the rate of the Evanston children in 1949, after a period of exposure to sodium fluoride of 23–34 months, is lower than the 1946 and 1947 rates.

Although only white school children were included in comparisons with other cities, in Evanston proper, all children in the given age groups from the public and parochial schools were included. Therefore, the rates given in Table 3 include all the children of proper age.

The 1949 dental survey (Table 3) (8), conducted on 12-, 13-, and 14-year old Evanston school children after 23–34 months of exposure to fluoridated water, indicated a reduction of approximately 12.9 per cent in the caries experience of the permanent teeth when compared to the base line examinations of students in the same age groups. The lowered caries rate in the 1949 group of 12-, 13-, and 14-year old children was apparently due to the fluoridated water. A reduction was found in the permanent-teeth dental caries experience rates of all three age levels. The topical application of sodium fluoride, however, was not entirely ruled out. A determined effort was made to keep accurate records of its use. The frequent visits to the school by the dental team may be a factor influencing the students toward the practice of good oral hygiene and better care of their teeth.

In March 1952 Hill (9) presented the results of examinations on 6-, 7-, and 8-year old Evanston children who

had been exposed to fluoridated water for a period of 47–58 months. Reduction in number of decayed, missing, and filled teeth per 100 children (DMF) of the permanent teeth was indicated in all three age groups. The average reduction for the group was 46.42 per cent below the 1946 base line rate for the same age group.

Occurrence of Fluorides in Foods

It is known that fluorine compounds are present in numerous foods, the amount varying with the type and source of the foods. The foods analyzed in the Evanston laboratory included soup, rice, baby foods, and cereals. A summary of Martin's findings (10) is given in Table 4. In obtaining materials to be analyzed for fluorine content (food, bones, and teeth) care was taken to use only those from Evanston and vicinity.

Martin's (10) explanation of the results is as follows: "The analyses showed the chicken soups to be higher in fluorine content than the other soups analyzed. In an attempt to explain this fact, some of the ingredients were analyzed. The results revealed chicken bones to contain 205 ppm fluorine, and vegetable protein, 1.8 ppm fluorine. The other soups contained sodium glutamate, which has a fluorine content of 8.4 ppm fluorine. This may be an explanation of the higher fluorine content of chicken soup. In an analysis of baby foods, Pablum was found to contain 11.2 ppm fluorine and Pabena, 5.3 ppm fluorine. The fluorine content of these foods may be due to the bone meal they contain, which has a natural high fluorine content." Martin (10) gives further detailed analyses of the amount of fluorides found in bones and teeth.

TABLE 5

*Fluorine Content of Fresh Vegetables Cooked in Water With and Without Fluorine**

Vegetable	Fluorine—*ppm*				
	Raw Water	Treated Water			
		0.0	1.0	2.0	5.0
Carrots	0.14	0.17	0.81	1.75	3.61
Beans	0.20	0.21	0.96	1.72	4.32
Peas	0.22	0.28	1.22	2.02	3.86
Spinach	0.84	1.00	2.02	2.85	4.99
Cabbage	0.23	0.29	1.13	1.88	4.92
Beets	0.21	0.28	0.60	1.16	1.88

* The vegetables were cooked by the saucepan method. All results were based upon fresh weight. The data were taken from "Determination of Fluorine in Foods, Bones, and Teeth" (10).

TABLE 6

*Fluorine Content of Fresh Vegetables Cooked in Water With and Without Fluorine**

Vegetable	Fluorine—*ppm*				
	Raw Water	Treated Water			
		0.0	1.0	2.0	5.0
Carrots	0.14	0.18	0.51	0.69	1.02
Beans	0.20	0.19	0.52	0.67	1.23
Peas	0.22	0.25	0.84	1.08	1.52
Spinach	0.84	0.76	1.13	1.63	2.81
Cabbage	0.23	0.23	0.55	0.79	1.03
Beets	0.21	0.26	0.44	0.57	0.78

* The vegetables were cooked in a pressure cooker. All results were based upon fresh weight. The data were taken from "Determination of Fluorine in Foods, Bones, and Teeth" (10).

Fluorine Content of Vegetables

In August 1947, Martin (11) conducted a study as a part of an investigation for the purpose of providing information on the probable amount of fluorine ingested in the complete diet. An analysis of foods cooked in water

containing fluorides in various strengths was made. Briefly, Martin concluded that vegetables cooked in water containing fluorides do absorb fluorine in proportion to the fluorine content of the water. Also, vegetables that were cooked in a saucepan absorb more fluorine than vegetables cooked in a pressure cooker. Frozen vegetables absorbed more fluorine than fresh vegetables when cooked in water containing 5.00 ppm fluorine, but little difference was noted when the fluoride concentration of the water was 1.0–2.0 ppm (Tables 5 and 6).

flushed, thus easily removing the scale. Gravity feed from the machine to the point of application is used in this installation; however, when it is necessary to use an ejector in applying the solution, much faster scaling must be expected.

Sodium fluoride can be purchased either in 100-lb paper bags or in 375-lb barrels or fiber drums. Although a savings of approximately 20 cents per 100 lb can be realized by purchasing in paper bags, caking has given some trouble when the chemical remains in storage for several months. The lumps

TABLE 7

Cost of Treatment With Sodium Fluoride at Evanston

	1947*	1948	1949	1950	1951
Treated—*mil gal*	3,879.817	5,005.463	4,763.272	4,753.115	4,611.120
NaF Used—*lb*	72,876	88,612	86,178	83,947	81,213
Avg. Cost per 100 lb—$	10.35	10.10	10.56	10.99	11.21
Cost per mil gal—$	1.94	1.79	1.91	1.94	1.97
Pop. Served	80,000 (est.)	83,000 (est.)	86,000 (est.)	88,441	88,441
Cost per Person per Year—$	0.094	0.108	0.106	0.104	0.103

* The fluoridation was started on Feb. 11, 1947.

Plant Operation

From the operation standpoint, sodium fluoride has been a very satisfactory chemical to apply. It dissolves readily (saturated solution—4 per cent), which means that less water and smaller dissolving chambers may be used than for sodium silicofluoride. It is only mildly corrosive—when tap water has a pH of 7.6, the water leaving the dissolving chamber has a pH of 7.7—but there is a gradual build-up of a hard, white scale, probably calcium and magnesium fluoride, on the inside of the solution lines. This problem has been solved, however, by using 2-in. rubber hose for the solution lines. The hose is removed approximately once a year, and is flexed and then

tend to clog the dry-feed machine and interrupt the flow of chemical. As no caking has occurred in the barrels or drums, all recent orders have been specified in drums.

As shown in Table 7, treatment costs have remained fairly constant over the five-year period from 1947 to 1951. The average cost has been $1.91 per mil gal treated. Recent increases in shipping charges, however, will probably bring the cost to something more than $2.00 per mil gal in 1952. Equipment purchase and installation costs have increased so much since 1947 that the cost of the Evanston installation would give little useful information to those contemplating fluoridation now. Maintenance costs have been so low

that they constitute a negligible factor. Labor could be prorated on the basis of the proportion of the operator's time spent in handling the chemical. No extra labor has been employed, however, and, inasmuch as one man operates the entire filter plant and all the chemical feeders, labor has not been considered in the cost of applying the fluoride.

When the application of sodium fluoride was started, Feb. 11, 1947, daily water samples were taken at the filter plant and at eight scattered locations on the distribution system.

TABLE 8

*Fluorine Concentration in Water the First Week Added**

Distribution Point	Fluorine—*ppm*					
	2/11/47	2/12/47	2/13/47	2/14/47	2/15/47	2/17/47
Lab.	0.05	0.95	1.00	0.95	1.00	1.00
1	0.00	0.35	0.85	0.90	1.00	1.00
3	0.00	0.43	0.80	0.90	1.00	1.00
6	0.00	0.45	0.90	0.95	1.00	1.00
8	0.00	0.80	0.95	1.00	1.00	1.00
13	0.00	0.80	0.95	1.00	1.00	1.00
14	0.00	0.15	0.75	0.85	0.90	0.95
15	0.00	0.90	0.96	1.00	1.00	1.00
4A	0.00	no test	0.50	0.80	0.90	0.95

* All samples collected between 9:00 and 10:00 AM.

Table 8 shows the fluoride concentration during the first week of operation. After the fourth day, the concentration at the extreme ends of the distribution system was almost identical to that found at the plant. This low loss of fluoride is shown even more strikingly in Table 9 which gives the number of analyses made during the five-year period of fluoridation. In all the tests made, an average loss of only 0.02 ppm is shown between the filter plant tap and the distribution system sampling points. This table also shows how closely the designated dosage of 1.00 ppm has been applied. Obviously, such close tolerances in the application of sodium fluoride must be maintained in order to insure the scientific validity of the overall study.

An unusual operating procedure used at Evanston may be of interest. Unlike other water works chemicals, such as chlorine, alum, carbon, ammonia, or lime, which are lost or removed by the treatment process, sodium fluoride remains in the finished water in almost the exact proportions in which it is added. This is especially true when it is added to the filter effluent. During most of 1949 and 1950, extensive changes and additions were being made to the Evanston plant, and it was necessary to operate without the benefit of low-lift Venturi meters. Chemical dosages were set according to previous records of low-lift pump capacities in the various combinations. These rates were also checked with the high-lift pumpage rates and fluctuations in the clear-well levels. The best check on the calculated pumpage rates, however, was the fluoride analysis of the tap water. By keeping the sodium

TABLE 9

Fluoride Analysis of Evanston Water

Year	No. of Determinations		Avg. F Content—*ppm*		Variations in F Content at Plant Tap	
	Filter Plant Taps	Distr. System Taps	Filter Plant Taps	Distr. System Taps	Days Over 1.15 *ppm*	Days Under 0.85 *ppm*
1947	354	302	1.05	1.03	2	1
1948	358	305	1.05	1.04	2	0
1949	365	255	1.03	1.02	0	0
1950	365	256	1.03	1.01	1	9
1951	363	144	1.04	1.01	2	0
Total	1,805	1,262	1.04 (avg.)	1.02 (avg.)	7	10

fluoride dosage constant, the authors were able to raise or lower the estimated pumpage rates to a fairly accurate figure. Although the fluoride determination is not recommended as a means of measuring water, even now that the new plant is complete, it is a convenient way of preventing large errors in the metering devices.

Summary

The purpose of the Evanston dental caries study was given full publicity in the newspapers, on the radio, and through all interested organizations that could be reached. No promises were made concerning the reduction in the caries rate, but cooperation was asked with the possibility of benefit to the children of the present generation. This procedure has resulted in practically no opposition to the program.

The results of the 1949 examinations of the 12-, 13-, and 14-year age group after 23–34 months of exposure to fluoridated water showed a reduction of approximately 12.9 per cent over the base line group. Although the results were inconclusive, a downward trend seemed to be indicated.

The completion of the examinations of 6-, 7-, and 8-year old children in 1951 after 47–58 months of exposure showed an average reduction of 46.42 per cent in the caries rate of the permanent teeth. These results are considered statistically significant.

The analysis of foods showed that fluorine is a constituent of the daily diet of people in the study area. There was no appreciable difference in the amount of fluorine absorbed by frozen and fresh vegetables in water containing 1–2 ppm of fluorine. Vegetables cooked in an open saucepan, however, do absorb more fluorine than those cooked in a pressure cooker.

With proper feeding equipment and adequate laboratory control, the danger of overfeeding and the hazards to employees are minimized. Application of sodium fluoride at Evanston has caused less maintenance and operating difficulty than any other water works chemical. Chemical cost during five-year period averaged $1.91 per mil gal treated, or 10.5 cents per person per year.

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Problems in the Design and Operation of a Booster Pumping Station

By R. L. Dobbin

A paper presented on May 28, 1952, at the Canadian Section Meeting, Montreal, Que., by R. L. Dobbin, Gen. Mgr., Peterborough Utilities Com., Peterborough, Ont.

IN 1948, Peterborough, Ont., started construction of a new civic hospital on the high ground west and north of the city. This location presented a problem in water supply to the utilities commission, as the buildings were 1,500 ft away from the nearest water main and at such an elevation that normal city water pressure would not furnish a satisfactory supply. In the preceding summer, during periods of heavy consumption, residential areas below the hospital had complained of poor pressure. Consequently, any new system had to include these areas. It was decided that the surest delivery would be obtained by using an elevated tank supplied through a booster pump from the nearest trunk main. The area to be supplied was 105 acres, or an estimated 525 dwellings.

Because of the area to be fed, the elevated tank size was fixed at 60,000 gal. The height of the tank was set to provide 20 psi pressure on the upper floor of the hospital. The supply is taken from a 14-in. trunk main, 3,900 ft from the elevated tank. The booster station is located on public school property adjacent to the trunk main. An 8-in. main feeds the elevated tank and adjacent residential areas.

Construction

The first step in the construction program was the laying of the 8-in. feeder main. This main, 3,900 ft long, is made of cast iron, Class 150, bell and spigot. A two-conductor, lead-covered cable was laid in the trench with the pipe to connect pump controls to tank controls. Underground cable was chosen because no pole lines existed in this area at the time. This foresight was wasted, however, for when the time arrived to use the cable, it had been broken in several places by the repeated excavations for water and sewer services in this new area, and it was not considered economical to locate and repair the breaks.

After the feeder main was laid, construction of the tank and pumphouse proceeded simultaneously. The concrete foundations for the tank were constructed by the commission's forces. The height of the elevated tank above its foundations was 96 ft to the bottom of the tank and 115 ft to the top of the tank.

The pumphouse was erected by the commission's forces except for minor details. Foundations were of monolithic concrete and the superstructure was wood frame with brick veneer, insulated with rock wool and sheeted inside with asbestos board. The roof was wood, of cottage type, with asphalt shingles. Power for the pumps was supplied by underground cable at 2,300 v to transformers in a protected enclosure on the ground floor.

Equipment

The pumping equipment originally installed was one 500-gpm, two-stage centrifugal pump driven by a 40-hp, 3-phase, 1,750-rpm induction motor. This capacity was chosen in order to provide a minimum of two fire streams. The pump on one end of the line and the tank on the other would usually make available four fire streams. The discharge was fitted with a tilting-disk check valve and a 4-in. crest meter. The pump is controlled by a pressure switch * located in the pumphouse. This switch is the mercury-tilt type combined with a time delay mechanism. The time delay is used on the start operation to prevent "hunting." Gages were installed to indicate and record water pressure in the booster system. The building is heated in the winter by three 1-kw electric heaters. The maintenance man connects the number of heaters required each day when he makes his daily tour.

Operating Difficulties

This system was placed in operation late in the fall of 1949 and functioned without appreciable difficulties at first, but troubles soon developed. One difficulty encountered was noise in consumer premises. Initially the noise was considered a small nuisance that only people with acute hearing could detect, and one to which they would soon become accustomed. As time went one, however, residents compared notes, and the complaints began to increase. The most serious came from consumers on the suction side of the pump, who were as much as 600 ft away from the pumphouse on a ring main system and on mains ranging in size from 5 to 14 in. The volume of noise in the house seemed to vary with the size of the water service. Sometimes, however, the interior piping of the houses amplified the noise.

It was found that the noise in the houses stopped when the cellar stop valve was closed, suggesting transmission of vibration through the pipes. Dresser couplings with rubber gaskets were installed, therefore, in both suction and discharge lines. These couplings provided flexible connections from pipes to pumps, but did not eliminate the noise.

Next, it was found that throttling the pump from 500 to approximately 175 gpm eliminated the noise nuisance. This condition was not satisfactory, however, because it reduced the available pumping capacity for fire purposes. Experts examined the pump, listened to the sounds it produced in the houses, and decided there was some vibrating section in the pump, not detectable by normal tests, and that the pump should be changed. Before getting another pump, however, there were other problems to consider.

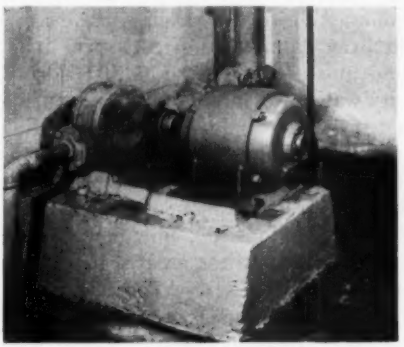


Fig. 1. 125-gpm Pump Used for Normal Pumpage

Pump is installed with its own separate set of pressure controls, check valve, and 2-in. water meter.

* Tanktrol, a product of Automatic Control Co., St. Paul, Minn., was used.

The two-stage, 500-gpm pump had a high shutoff head, and, combined with the positive pressure in the suction line, created starting pressures of 150 psi or 350 ft in the booster system. Inasmuch as the modern hot water tank is weak, this pressure was considered too extreme. To eliminate this problem, an air cushion was placed in the line. This device, to be satisfactory, however, was too bulky for the building and was discarded. A pressure relief valve was then installed across the pump but it operated with such great noise that it was removed.

started from time to time. A second check, in series, proved a remedy.

The main pumpage requirements of the district, consisting of the 250-bed hospital and 210 houses, have been supplied uneventfully by this arrangement to the present.

The larger pump continued to present a problem, however. When the elevated tank was off the line, it was difficult to operate the large pump because, in such a condition, this two-stage pump and its high shutoff head, operating directly into the distribution mains, would create excessive pressures

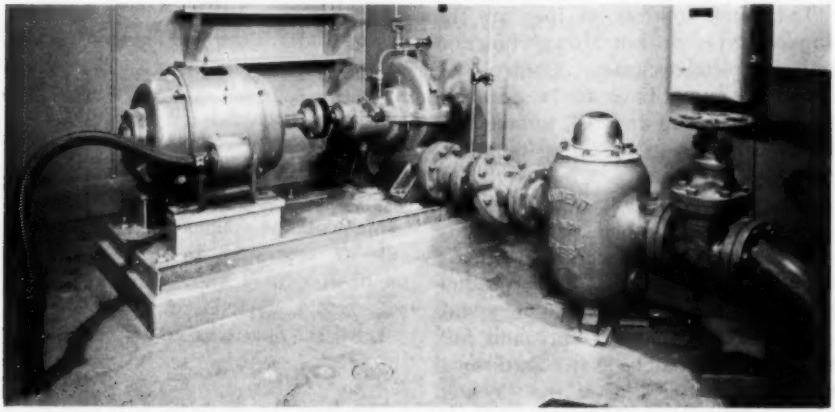


Fig. 2. 500-gpm Pump Used for Fire and Heavy Pumpage Periods
This supplementary pump is single stage and operates at 1,750 rpm.

As the maximum daily pumpage was 126,000 gal, it was decided to install, for the main volume of pumping, a 125-gpm pump (Fig. 1) that had been in storage and to use the larger pump only for fire. It was expected that the small pump would create little or no pressure surges in the main and would operate on a relatively low electric demand. The small pump was installed with its own separate set of pressure controls, check valve, and 2-in. water meter. As there was only one swing check valve on the discharge, chatter that were not easy to control. The manufacturer was requested to supply a single-stage pump having a relatively low shutoff head. The manufacturer, at no extra charge, supplied a new single-stage, 1,750-rpm pump rated at 500 gpm at 196 ft (Fig. 2). The shutoff head is 206 ft. The pressure problem was solved by this new pump, but the noise problem was only partially relieved. The noise in consumers' dwellings was reduced, but not below the audible level. It was then assumed that the noise in the homes

was caused by high-velocity flow in the mains.

Station Difficulties

Other difficulties occurred in operating the station. One extremely cold night frost action dropped open a bottom-hinged sash in the building. The cold air from this window froze the pump and seized the shaft. When the control energized the motor, the flow of current ruptured a lightly fused connection on the 2,300-v supply, cutting off all power. The equipment froze solid, but only some small piping was damaged.

The pump controls, as they are the simplest type, do not always function with complete accuracy. Controls on the small pump have to be adjusted seasonally, spring and fall, to take care of the variation in operating temperatures.

The control for the larger pump presented a difficult problem. The velocity head at the pump created by a flow of 500 gpm in the 8-in. discharge line was approximately 22 ft. Pressure settings for the tank, empty and full, varied approximately 11 ft. Static head to the low-water line of the elevated tank was 196 ft. When pressure in the trunk main feeding the pump was constant, the control functioned satisfactorily. In periods of heavy summer draw, however, pressure in the trunk main fell, causing the suction pressure to drop, and, consequently, rate of pumpage fell, too, because of the higher head against which it was necessary to pump. Velocity head was reduced so that the control would not shut off the pump, and so that the tank would overflow until the suction pressure increased. When the larger pump, normally used only for fire, starts up during periods of heavy pumpage, however, it is necessary that it be switched off and on manually. This switching trips the relays, and the pump will not start again until a large draw occurs. A water pressure alarm switch was installed in the boiler room of the hospital, adjacent to the tank, to warn of high or low pressures.

To relieve the small pump, the starting impulse is given to the larger pump only when the water pressure drops approximately 5 ft below the starting pressure of the small pump. This drop occurs only through failure of the small pump or heavy draws resulting from fire use.

TABLE 1

Booster Station, Tower, and Supply Main Costs

60,000-gal. elevated tank	
Tank, supply, and erection	$18,658.64
Labor and materials for foundation and fence	1,169.57
	$19,828.21
Booster pumping station	
Materials and equipment*	5,100.11
Labor	1,514.22
	$ 6,614.33
8-in. feeder main†	
Labor and materials	$18,705.72
Total	$45,148.26

* The figure given for the booster pumping station equipment does not include the cost of water meters, electric transformers, recording meter, or small pump.
† The feeder main is 3,900 ft long and connects the pumphouse and the tank.

Costs

In 1951 the pumps handled 44.68 mil gal of water, of which 5 per cent went through the fire pump. The power cost for the year was $735. Heat and light cost $90, or a total of 2.2 cents per 1,000 gal. A breakdown of the costs of the booster station, tower, and supply main is given in Table 1. The 250-bed hospital used 24 mil gal of water, or 263 gpd per bed. The 210 houses used the remainder, or 270 gpd per house.

Preparation of Recommended Procedure for Sealing Abandoned Wells

Committee Report

A report by Committee E4A—Deep Wells, presented on May 8, 1952, at the Annual Conference, Kansas City, Mo., by James C. Harding, Chairman; Comr. of Public Works, Westchester County, White Plains, N.Y.

Committee on Deep Wells

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THE Board of Directors of the American Water Works Assn. in January 1950 directed its Committee E4A—Deep Wells, to prepare specifications for the sealing of wells. An investigation of the subject was started immediately and in May 1950 a paper was presented at the Philadelphia Convention by O. J. Muegge, member of this committee, entitled "Sealing Abandoned Wells." Criticisms of this paper were invited and the first draft of the "recommended procedure" was submitted to the Association at the Miami Convention in 1951.

The first draft was sent to state health departments and other regulatory agencies, and to well drillers, consulting engineers, and others whose opinions were particularly desired. Many answers were received and, as a result, a number of changes were found to be desirable. These changes are embodied in the final draft, which the Board of Directors has approved and is published as an "addendum" to specifications AWWA A100—Deep Wells (*see* p. 965, this issue).

The addendum is not a true specification but is rather a recommended procedure. This form was decided upon because of the breadth of the field of well construction, the multiplicity of possible combinations of formations that wells penetrate, and because tools, equipment, and the "know-how" essential in the use of certain methods of sealing are not available in all sections of the country. No worth-while single specification capable of sufficiently broad application could be prepared.

The committee feels the recommended procedure set forth sufficient information to enable an engineer or water works operator grounded in well supply work to select the methods which apply to any particular well. This information should at least suffice to warn him of the pitfalls inherent in the sealing of certain types of wells and, as a result, he is more likely to call for skilled assistance if he is unsure of his own qualifications.

Inasmuch as most of the criticisms of the first draft of the recommended procedure came from experienced sanitary engineers and well drillers who naturally think of the most difficult rather than the average job, it is possible that the committee has overemphasized the troubles which may be encountered in sealing wells.

Before selecting a method for sealing abandoned wells, the engineer or water works operator should read the objectives of the recommended procedure several times. These objectives include:

1. Eliminating physical hazard.
2. Preventing contamination of ground water.
3. Conserving yield and hydrostatic head of aquifers.
4. Preventing intermingling of desirable and undesirable waters.

The Committee on Deep Wells is grateful for the criticisms and suggestions sent it from many well-informed sources. The committee regrets that it was frequently necessary to disregard the suggestions, as many were applicable only to certain relatively rare types of wells, or to formations that do not occur widely in this country. In addition, some of the recommendations were considered highly argumentative. A few of the criticisms and suggestions the committee did not adopt follow.

Enforcement Provisions

Several critics thought that there was little object in disseminating information on the sealing of wells unless the use of such information was made mandatory by rules and regulations, codes, or other instruments of law that would provide penalties for those not properly sealing abandoned wells. These critics felt that this committee should formulate the enforcement provisions. They pointed out that the average well owner, public or private, will not spend money to "bury his dead horse" unless someone forces him to do it. This state of affairs is unfortunately true. After investigating, the committee found that not more than two or three states, if any, adequately enforce the requirement that abandoned wells be sealed.

No enforcement provisions of nationwide applicability could be formulated because of the vast differences in conditions in the various states. Also, it is believed that the American Water Works Assn. is not the proper agency to formulate a code containing such provisions, the enforcement of which might depend on the laws of the individual state. The recommended procedure sets forth information that is sufficient to enable the individual state regulatory body having jurisdiction or the Conference of State Sanitary Engineers to draft, without too much difficulty, an instrument of enforcement, such as a code, for the individual state. The committee suggests that this problem is of sufficient importance to warrant as prompt action as possible by these agencies. The American Water Works Assn. should help in the prep-

aration of the codes if called upon, and the local sections might well assist in the passage of needed legislation.

Definition of Abandoned Well

The committee did not consider it feasible to make any general statement on when a well should be considered abandoned, as the determination should be based on conditions peculiar to the individual well. One state health department suggested that a well be considered abandoned when maintenance and operation stop and are not resumed within a period of one year. The committee does not concur. A farmhouse or factory might well stand idle for much longer than a year but would still need its water supply when it reopened. Many municipalities, including New York City, have well fields that are operated only when the yield of surface supplies is insufficient to meet demands. The wells may not be operated for several years and maintenance may be unnecessary. Good practice demands, of course, that, if there is any prolonged period of doubt whether or not to abandon the well, the top should be temporarily plugged in a substantial manner with a screw cap or welded plate.

Economic Aspects

A prominent consulting engineer has observed that, in recommending clay or sand as a sealing material for certain types of wells, the committee is making "a sop to financial rather than public health and welfare reasoning." A well-known driller who takes the other side states, however: "The difficulty usually encountered in sealing wells is from the customer not wanting to stand the expense of adequate sealing of abandoned wells. For this reason, it must be kept as simple and inexpensive as possible." The committee is inclined to agree with the driller, at least until such time as the practice of sealing abandoned wells becomes the rule rather than the exception.

Mandatory Grouting

Many critics expressed the opinion that wells should always be grouted for their entire depth with grout or neat cement. Some even recommended that this grouting should always be done by the pressure method. The committee considers both the filling of the entire depth of all wells with concrete and the grouting by the pressure method unnecessary and too expensive when the problem of well sealing is viewed from a broad standpoint. A leading well-drilling company stated: "Not one out of a hundred of the most competent well drillers in the country is equipped with pumps, tools, tanks, appurtenances, or experienced operators to do a real job of pressure cementing an old well."

Expert Advice

Under many circumstances, the recommended procedure recommends that a competent well driller or consulting engineer be employed, or that the services of a representative of the state health department be obtained. Some critics even recommend this procedure for every well-sealing job. Except for difficult operations, this procedure would entail an unnecessary expenditure. It is doubtful whether most state health departments are sufficiently staffed to service a large number of requests. Also, the committee feels that many consultants and health department engineers could not handle a complicated well-sealing job.

Preliminary Information

Several authorities have expressed the opinion that considerable study and expense should be undertaken to secure accurate information on the construction of the well, including depth of casings and their conditions, location of crevices, and nature of formations. The committee feels that if such information is available, it should be carefully studied, and that information should also be obtained on the general characteristics of nearby wells. It would appear, however, that expensive investigations, including caliper surveys, photographing, and electric logging, as some have proposed, are generally unwarranted.

Before sealing an abandoned well, it is almost always good practice to run a bailer or string of tools to the bottom to make sure that there are no obstructions which might cause bridging of the sealing material.

Oil Wells and Mine Shafts

It has been said that the recommended procedure should also include methods for sealing oil wells and mine shafts. It is realized that there is frequently grave danger that these sources will contaminate aquifers of potable water. The methods, equipment, and personnel that would be used for work of this kind, however, would only occasionally be comparable to those normally used for the sealing of water wells. Furthermore, the sealing of oil wells and mine shafts, except in very rare instances, comes outside the duties or capabilities of the water works engineer or operator.

Conclusion

In preparing the recommended procedure for sealing abandoned wells, it was not the intention of the committee to describe all methods and materials that could be used advantageously. In all probability, many experienced drillers and engineers have found other methods and materials that, in particular jobs, have worked better than those set forth by the committee. The committee feels, however, that it has covered the ground for broad general usage. Inasmuch as this is a pioneer treatise on a subject about which little has been published, revision and amplification will probably be necessary.

Addendum
Standard Specifications for Deep Wells

Introduction

The "Standard Specifications for Deep Wells" were adopted by the Board of Directors of AWWA on May 10, 1946. These specifications were prepared by Committee E4A, which was asked by the Board of Directors in January 1950 to prepare a specification for the sealing of abandoned wells. The following is a "recommended procedure" rather than a "specification" and constitutes Sec. A13 of the "Standard Specifications for Deep Wells." Section A13—Sealing Abandoned Wells—was adopted by the AWWA Board of Directors on June 18, 1952.

Section A13—Sealing Abandoned Wells

Sec. A13.1—General

Unsealed abandoned wells constitute a hazard to public health and welfare. The sealing of such wells presents a number of problems, the character of which depends upon the construction of the well, the geological formations encountered, and the hydrologic conditions. To seal an abandoned water well properly, several factors must be considered: [1] eliminating physical hazard; [2] preventing contamination of ground water; [3] conserving yield and hydrostatic head of aquifers; and [4] preventing intermingling of desirable and undesirable waters.

The basic concept of proper sealing of abandoned wells is the restoration, as far as feasible, of the controlling geological conditions that existed before the well was drilled or constructed. If this restoration can be accomplished, all the objectives of sealing wells heretofore presented will be adequately fulfilled.

To seal an abandoned well properly, the type of occurrence of the ground water at the particular well to be sealed must be recognized. If the ground water occurs under water table conditions, the chief problem is that of sealing the well with impermeable material to prevent the percolation of surface water through the original well opening or along the outside of the casing to the water table. If the ground water occurs under artesian conditions, the sealing operations must confine the water to the aquifer in which it occurs, thereby preventing loss of artesian pressure by circulation of water to the surface, to a formation containing no water, or to one containing water under a lower head than that of the aquifer being sealed.

Usually a well should be checked before it is sealed in order to insure freedom from obstructions that may interfere with effective sealing operations. This check is especially important in wells that may conduct contaminated or otherwise objectionable water into aquifers yielding potable waters. Removal of liner pipe from some wells may be necessary to assure placement of an effective seal. If liners or casings opposite water-bearing zones can-

not be readily removed, they should be split with a casing ripper to assure the proper sealing of water-bearing zones with the sealing material. At least the upper portion of the casing should be removed to prevent surface water from entering the water-bearing strata by following down the casing. This operation is not always essential if the annular space around the outside of the casing was cemented when the well was drilled.

Concrete, cement grout, or neat cement, when used as a sealing material below the water level in the well, should be placed from the bottom up by methods that will avoid segregation or dilution of material. Piping cementing materials directly to the point of application or placement by means of a dump bailer or tremie is recommended. Other sealing materials referred to hereafter, except mud-laden or special clay fluids, can, as a rule, be gradually introduced into the top of the well.

Employment of a competent well driller to accomplish sealing of a deep or flowing well or one in creviced formation will usually be advisable. The driller should be equipped to remove obstructions interfering with sealing operations and to provide for placing the sealing materials in the most effective manner. His knowledge of well construction and the geological conditions of the region will be valuable in the proper abandonment of a well just as it is in the construction of a new well. It may be advantageous to call in a consulting engineer or a representative of the state health department or other department having jurisdiction.

The recommendations contained herein pertain to wells in consolidated and unconsolidated formations, to those of small or large diameter, to test wells, and to so-called "stovepipe wells." Each sealing job should be considered as an individual problem and methods and materials should be determined only after carefully considering the objectives outlined in the first paragraph of this section.

Sec. A13.2—Wells in Unconsolidated Formations

(*See* Appendix, Sec. A4, Types 1–5.) Abandoned wells extending only into unconsolidated formations near the surface and containing water under water table conditions normally can be adequately sealed by filling with concrete, grout, neat cement, clay, or clay and sand. In the event the water-bearing formation consists of coarse gravel and producing wells are located nearby, care must be taken to select sealing materials that will not affect the producing wells. Concrete may be used if the producing wells can be shut down for a sufficient time to allow the concrete to set. Clean, disinfected sand or gravel may also be used as fill material opposite the water-bearing formation. The remainder of the well and always the upper portion should be filled with clay, concrete, grout, or neat cement to exclude surface water. The latter method, using clay as the upper sealing material, would be especially applicable to large-diameter abandoned wells.

In gravel-packed, gravel-envelope, or other wells in which coarse material has been added around the inner casing to within 20–30 ft of the surface, sealing outside the casing is very important. Sometimes this sealing may require removal of the gravel or perforation of the casing.

Sec. A13.3—Wells Extending Into Creviced Rock Formations

(*See* Appendix, Sec. A4, Types 8–10.) Abandoned wells that pene-

trate limestone or other creviced or channelized rock formations lying immediately below the surface deposits should preferably be filled with concrete, grout, or neat cement to assure permanence of the seal. The use of clay or sand in such wells is not desirable because fine-grained fill material may be displaced by flow of water through crevices or channels. Alternate layers of coarse stone and concrete may be used for fill material through the water-producing horizon if limited vertical movement of water in the formation will not affect the quality or quantity of water in producing wells. Only concrete, neat cement, or grout should be used in this type of well as seal material in that portion of the well between a point 10–20 ft below and a point above the bottom of the casing, and also to form a plug above the creviced formation. Clay or sand may be used to fill the upper part of the well.

Sec. A13.4—Wells Extending Into Noncreviced Rock Formations

(*See* Appendix, Sec. A4, Types 6 and 7.) Abandoned wells encountering noncreviced sandstone or other water-bearing consolidated formations below the surface deposits may be satisfactorily sealed by filling the entire depth with clay, provided there is no movement of water in the well. Clean sand, disinfected if other producing wells are nearby, may also be used through the sandstone up to a point 10–20 ft below the bottom of the casing. The upper portion of this type of well should be filled with concrete, neat cement, grout, or clay to provide an effective seal against entrance of surface water. If there is an appreciable amount of upward flow, pressure cementing or mudding may be advisable.

Sec. A13.5—Wells Extending Into More Than One Aquifer

Some special problems may develop in sealing wells extending into more than one aquifer. These wells should be filled and sealed in such a way that exchange of water from one aquifer to another is prevented. If no appreciable movement of water is encountered, filling with concrete, neat cement, grout, or alternate layers of these materials and sand will prove satisfactory. When velocities are high, the procedures outlined in Sec. A13.6 are recommended. If alternate concrete plugs or bridges are used, they should be placed in known nonproducing horizons, or at frequent intervals when location of the nonproducing horizons is not known. Sometimes, when the casing is not grouted or the formation is noncaving, it may be necessary to break or slit the casing to fill any annular space on the outside.

Sec. A13.6—Wells With Artesian Flow

(*See* Appendix, Sec. A4, Type 11.) The sealing of abandoned wells that have a large movement of water between aquifers or to the surface requires special attention. Frequently the movement of water may be sufficient to make sealing by gravity placement of concrete, cement grout, neat cement, clay, or sand impractical. In such wells, large stone aggregate (not more than one-third of the diameter of the hole), lead wool, steel shavings, a well packer, or a wood or cast-lead plug or bridge will be needed to restrict the flow to permit the gravity placement of sealing material above the formation producing the flow. If preshaped or precast plugs are used, they should be several times longer than the diameter of the well to prevent tilting.

Inasmuch as it is so important in wells of this type to prevent circulation between formations or loss of water to the surface or to the annular space outside the casing, it is recommended that pressure cementing with neat cement and the minimum quantity of water that will permit handling be employed. The use of pressure mudding instead of this process is sometimes permissible.

In wells in which the hydrostatic head producing flow to the surface is low, the movement of water may be arrested by extending the well casing to an elevation above the artesian pressure surface. Previously defined applicable sealing methods to fit geological conditions can then be used effectively.

Sec. A13.7—Sealing Materials

A number of materials for sealing wells satisfactorily, including concrete, cement grout, neat cement, clay, sand, or combinations of these materials, are mentioned herein. Each material has certain characteristics and distinctive properties; accordingly, one material may be especially suited for doing a particular job. The selection of the material must therefore be based on the construction of the well, the nature of the formations penetrated, the material and equipment available, the location of the well with respect to possible sources of contamination, and the cost of doing the work.

Concrete is generally used for filling the upper part of the well or water-bearing formation, for plugging short sections of casings, or for filling large-diameter wells. Its use is cheaper than neat cement or grout and it makes a stronger plug or seal. If not properly placed, however, the aggregate is apt to separate from the cement, and concrete will not penetrate seams, crevices, or interstices.

Cement grout or neat cement and water are far superior for sealing small openings, for penetrating any annular space outside of casings, and for filling voids in the surrounding formation. When applied under pressure, it is strongly favored for sealing wells under artesian pressure or those encountering more than one aquifer. Neat cement is generally preferred to grout as it avoids the danger of separation.

Clay as a heavy mud-laden or special clay fluid applied under pressure has most of the advantages of cement grout and its use is preferred, particularly for sealing artesian wells, by many competent authorities, but others feel that it may, under some conditions, eventually be carried away into the surrounding formations.

Clay in a relatively dry state, clay and sand, or sand alone may be used advantageously, particularly under water table conditions where diameters are large, depths are great, formations are caving, and there is no need of achieving penetration of openings in casings, liners, or formations, or of obtaining a watertight seal at any given spot.

Frequently combinations of these materials are necessary. The more expensive materials are used when strength, penetration, or watertightness is needed, the less expensive materials being used for the remainder of the well. Cement grout or neat cement is now being mixed with specially processed clays and with various aggregates. Superior results and economies are claimed for such mixtures.

AWWA C207-52T

American Water Works Association

Tentative

STANDARD SPECIFICATIONS

for

STEEL PIPE FLANGES

These "Specifications for Steel Pipe Flanges" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of their use for any installation must be subjected to review by the engineer responsible.

Approved by the AWWA Board of Directors as "Tentative" May 9, 1952

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

Table of Contents

	Section		Section
Scope	1	Facing	6
Pressure Ratings	2	Gaskets	7
Sizes	3	Bolting	8
Marking	4	Tolerances	9
Materials	5	Attachment of Flanges to Pipe	10

This standard was developed by a joint committee of the American Water Works Assn. and the American Society of Mechanical Engrs. which began its work in 1945. The scope of the project was described as follows:

1. The establishment of agreement as to the correct engineering basis for the design of bolted flanged connections in the low-pressure, low-temperature field.
2. The establishment of dimensional standards in the field required by the American Water Works Assn., such that they would be acceptable also to the American Society of Mechanical Engineers Boiler Code Committee and, ultimately, to the American Standards Assn.

Joint Committee Personnel

F. S. G. WILLIAMS, *Chairman*

AWWA	*ASME*
R. E. BARNARD	D. B. ROSSHEIM
MARTIN ETTINGTON	N. O. SMITH-PETERSON
S. A. EVANS	E. O. WATERS
H. O. HILL	D. B. WESSTROM
S. L. KERR	F. S. G. WILLIAMS

In its extensive deliberations the committee had available the results of special research by industry representatives.

When the report of the joint committee was approved in 1951, it was agreed by ASME Secretary Davies that the standard should be processed and published by the American Water Works Assn. as an AWWA Standard.

For such further investigations as the subject may require, an AWWA Committee has been appointed to act under the Chairmanship of H. O. Hill. Serving with Mr. Hill are R. E. Barnard, Martin Ettington, S. A. Evans, S. L. Kerr, and F. S. G. Williams.

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Tentative Standard Specifications for

STEEL PIPE FLANGES

Introduction

Steel flanges have been used on steel pipe in the water works field since the first riveted steel water supply lines were installed with flanges attached by riveting. Unofficial flange standards, such as the riveted pipe manufacturer's standards, have been in common use for 50 years or more. Steel plate ring flanges and rolled angle flanges to match the drilling of existing cast valves and cast fittings have also been employed extensively.

The greatly increased usage of steel pipe for water works service during recent years has made standardization desirable. The first step toward this standardization was taken in 1942 by the Technical Standards Committee of the Steel Water Pipe Manufacturers Technical Advisory Committee to the American Water Works Assn. In June of that year a paper,* in which standards for slip-on steel ring flanges for welding to steel water pipe were proposed, was presented at the annual convention of the American Water Works Assn.

In 1945 at the request of the American Society of Mechanical Engineers, a joint committee having representation from both that society and the American Water Works Assn. was formed. The problem before this committee was that of establishing standard steel flanges having dimensions and pressure ratings commensurate with the pressures commonly encountered in water works service. Such standards are necessary because the existing lowest pressure standards for steel flanges are those having cold water service ratings of 230 psi (ASA B16e6, 150 psi primary service rating) which is far higher than is ordinarily needed in water service.

The generally accepted rules for the design of bolted flanged connections embrace all fields of usage and a wide range of pressure and temperature applications. In water works practice, within the scope of this standard, it is not necessary to deal with temperatures above the atmospheric range, and it is possible to restrict consideration to joints with soft gaskets and to flanges that are flat-faced. The designs were prepared in conformity with these limitations.

The object of the committee was to develop the proportions of a flanged joint utilizing slip-on steel flanges, with and without hubs, that are welded to steel pipe, and a sealing gasket inside the bolt circle made of $\frac{1}{16}$-in. thick cloth-inserted rubber.

Inasmuch as the welding-neck flange for butt welding to pipe is unusual in water works service, it was not felt necessary to provide standard dimensions for this type, but they may be used for Class E in accordance with the footnote under Table 3.

The committee gave careful consideration to the following: [1] the effect of new standards on existing equipment; [2] the fact that cast valves

* Hill, H. O.; Lewis, W. W.; & Easter, H. J. Fabricated Steel Ring Flanges for Water Pipe Service for Low Pressures and Low Temperatures. Jour. AWWA, 36:968 (Sept. 1944).

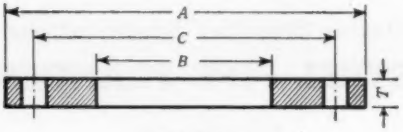


TABLE 1

AWWA Standard Steel Ring Flanges, Class B† and Class D‡*

Nominal Pipe Size *in.*	OD of Flange *A*—*in.*	Number of Bolts	Diam. of Bolt Circle *C*—*in.*	Diam. of Bolts—*in.*		Thickness of Flange—*in.*	
				Class *B*	Class *D*	Class *B* *T*	Class *D* *T*
6	11	8	9½	⅝	¾	11/16	11/16
8	13½	8	11¾	⅝	¾	11/16	11/16
10	16	12	14¼	⅝	⅞	11/16	11/16
12	19	12	17	⅝	⅞	11/16	13/16
14	21	12	18¾	¾	1	11/16	15/16
16	23½	16	21¼	¾	1	11/16	1
18	25	16	22¾	¾	1⅛	11/16	1 1/16
20	27½	20	25	¾	1⅛	11/16	1⅛
22	29½	20	27¼	¾	1¼	¾	1 3/16
24	32	20	29½	¾	1¼	¾	1¼
26	34¼	24	31¾	¾	1¼	13/16	1 5/16
28	36½	28	34	¾	1¼	⅞	1 5/16
30	38¾	28	36	⅞	1¼	⅞	1⅜
32	41¾	28	38½	⅞	1½	15/16	1½
34	43¾	32	40½	⅞	1½	15/16	1½
36	46	32	42¾	⅞	1½	1	1⅝
42	53	36	49½	1	1½	1¼	1¾
48	59½	44	56	1	1½	1¼	1¾

* The purchaser should specify the inside diameter of flange *B*. It is recommended that this dimension be ⅛ in. larger than the nominal outside diameter of the pipe.

† Water service rating at atmospheric temperature is 86 psi. These flanges have the same outside diameter and drilling as ASA B16b2 (25 psi cast-iron standard). They also have the same outside diameter, bolt circle, and number of bolts as Class 125 cast-iron flanges (ASA B16.1) but use smaller bolts.

‡ Water service rating at atmospheric temperature: sizes 6 to 12 in., inclusive, 175 psi; sizes larger than 12 in., 150 psi. These flanges have the same diameter and drilling as Class 125 cast-iron flanges (ASA B16.1). In sizes 24 in. and smaller they also match the ASA B16e 150-psi standard for steel flanges.

and fittings will always have flanges of large outside diameter, which cannot be reduced because of the wall thickness of such equipment; [3] the need for interchangeability of equipment through the medium of common drilling templates; and [4] the fact that standards could be based on the successful usage and good service records of existing installations.

A survey of water works users indicated that in sizes 48 in. and smaller it was desirable to maintain the outside diameter and drilling of flanged fittings and valves given in specification AWWA C500 and ASA B16.1. The

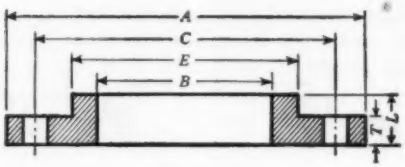


TABLE 2

AWWA Standard Steel Hub Flanges, Class B† and Class D‡*

Nominal Pipe Size *in.*	OD of Flange *A—in.*	Number of Bolts	Diam. of Bolt Circle *C—in.*	Diam. of Bolts—*in.*		Flange Dimensions for Class *B* and *D—in.*		
				Class *B*	Class *D*	Thickness *T*	Length Through Hub *L*	Diam. of Hub *E*
6	11	8	9½	⅝	¾	9/16	1¼	7 9/16
8	13½	8	11¾	⅝	¾	9/16	1¼	9 11/16
10	16	12	14¼	⅝	⅞	11/16	1¼	12
12	19	12	17	⅝	⅞	11/16	1¼	14¾
14	21	12	18¾	¾	1	¾	1¼	15¾
16	23½	16	21¼	¾	1	¾	1¼	18
18	25	16	22¾	¾	1⅛	¾	1¼	19⅞
20	27½	20	25	¾	1⅛	¾	1¼	22
22	29½	20	27¼	¾	1¼	1	1¾	24¼
24	32	20	29½	¾	1¼	1	1¾	26⅛
26	34¼	24	31¾	¾	1½	1	1¾	28½
28	36½	28	34	¾	1½	1	1¾	30½
30	38¾	28	36	⅞	1½	1	1¾	32½
32	41¾	28	38½	⅞	1½	1⅛	1¾	34¾
34	43¾	32	40½	⅞	1½	1⅛	1¾	36¾
36	46	32	42¾	⅞	1½	1⅛	1¾	38¾
42	53	36	49½	1	1½	1¼	1¾	45
48	59½	44	56	1	1½	1⅜	2½	51

* The purchaser should specify the inside diameter of flange *B*. It is recommended that this dimension be ⅛ in. larger than the nominal outside diameter of the pipe.

† Water service rating at atmospheric temperature is 86 psi. These flanges have the same outside diameter and drilling as ASA B16b2 (25 psi cast-iron standard). They also have the same outside diameter, bolt circle, and number of bolts as Class 125 cast-iron flanges (ASA B16.1) but use smaller bolts.

‡ Water service rating at atmospheric temperature: sizes 6 to 12 in., inclusive, 175 psi; sizes larger than 12 in., 150 psi. These flanges have the same diameter and drilling as class 125 cast-iron flanges (ASA B16.1). In sizes 24 in. and smaller they also match the ASA B16e 150-psi standard for steel flanges.

committee is continuing its work and will establish suitable dimensions for sizes up to 120 in.

The following AWWA standards are based on the establishment of two types of flange cross sections—the ring type slip-on flange (Table 1) and the hub type slip-on flange (Tables 2 and 3)—which may be used interchangeably if the dimensions given in the standards

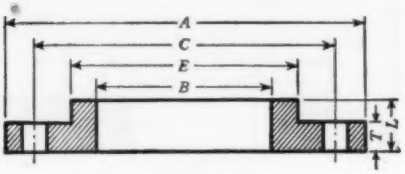


TABLE 3

*AWWA Standard Steel Hub Flanges, Class E**

Nominal Pipe Size *in.*	OD of Flange *A—in.*	ID of Flange *B†—in.*	Drilling			Flange Dimensions—*in.*		
			No. of Bolts	Diam. of Bolts *in.*	Diam. of Bolt Circle *C—in.*	Thickness *T*	Length Through Hub *L*	Diam. of Hub *E*
½	3½	0.88	4	½	2⅜	7/16	⅝	1 3/16
¾	3⅞	1.09	4	½	2¾	½	⅝	1½
1	4¼	1.38	4	½	3¼	9/16	11/16	1 13/16
1¼	4⅝	1.72	4	½	3½	⅝	13/16	2 5/16
1½	5	1.97	4	½	3⅞	11/16	⅞	2 9/16
2	6	2.44	4	⅝	4¾	¾	1	3 1/16
2½	7	2.94	4	⅝	5½	⅞	1⅛	3 9/16
3	7½	3.56	4	⅝	6	15/16	1 3/16	4¼
3½	8½	4.06	8	⅝	7	15/16	1¼	4 13/16
4	9	4.56	8	⅝	7½	15/16	1 5/16	5 5/16
5	10	5.66	8	¾	8½	15/16	1 7/16	6 7/16
6	11	6.72	8	¾	9½	1	1 9/16	7 9/16
8	13½	8.72	8	¾	11¾	1⅛	1¾	9 11/16
10	16	10.88	12	⅞	14¼	1 3/16	1 15/16	12
12	19	12.88	12	⅞	17	1¼	2 3/16	14⅜
14	21	14.19	12	1	18¾	1⅜	2¼	15¾
16	23½	16.19	16	1	21¼	1 7/16	2½	18
18	25	18.19	16	1⅛	22¾	1 9/16	2 11/16	19⅞
20	27½	20.19	20	1⅛	25	1 11/16	2⅞	22
24	32	24.19	20	1¼	29½	1⅞	3¼	26⅛
26	34¼		24	1¼	31¾	2	3⅜	28½
28	36½		28	1¼	34	2 3/16	3 7/16	30¾
30	38¾		28	1¼	36	2¼	3½	32¾
32	41¾		28	1½	38½	2¼	3⅝	35
34	43¾		32	1½	40½	2 5/16	3 11/16	37
36	46		32	1½	42¾	2⅜	3¾	39¼
42	53		36	1½	49½	2⅝	4	46
48	59½		44	1½	56	2¾	4⅛	52¼

* Water rating at atmospheric temperature is 230 psi. These flanges have the same diameter and drilling as Class 125 cast-iron flanges (ASA B16.1). In sizes 24 in. and smaller they also match the ASA B16e 150-psi standard for steel flanges.

† The purchaser should specify the inside diameter of the flange for nominal pipe sizes 26 to 48 in., inclusive. It is recommended that this dimension be 1/16 in. larger in diameter than the nominal outside diameter of the pipe. Welding neck flanges may be used if desired.

are used. It is assumed that either type is attached to the pipe by fillet welds located on the face and back of the flange. The user of these standards is free to select the type.

The committee was greatly aided by special research and testing conducted by Armco Steel Corp., Bethlehem Steel Co., and Taylor Forge and Pipe Works. The flange proportions established in the tables of these standards represent the best judgment of this committee and embody both research and experience.

Sec. 1—Scope

Flanges in this standard are intended for use with steel pipe meeting the requirements of specifications AWWA C201 and C202, and ASTM A-134, A-139, and A-211, or other equivalent specifications.

Sec. 2—Pressure Ratings

The following pressure ratings apply to flanges covered by this standard:

Class B—Flanges suitable for hydraulic pressures up to and including 86 psi. This rating is identical with that for Class B cast-iron pipe for a 200-ft. head of water.

Class D—Flanges suitable for hydraulic pressures as follows: sizes 6 to 12 in., inclusive, 175 psi; sizes larger than 12 in., 150 psi. These ratings are identical with those given in AWWA C500 and ASA B16.1 for cast-iron flanged valves and flanged fittings.

Class E—Flanges suitable for hydraulic pressures up to and including 230 psi, a rating which agrees with the ASA B16e, 150 psi standard at 100 F. The dimensions are identical with the 150 psi ASA standard sizes 24 in. and smaller, except flat-faced (*see* Sec. 6 herein).

The ratings are for water pressures under conditions and temperatures customary in water works service. The design pressure should include anticipated allowance for surge pressures. Test pressure for equipment using flanges in this standard shall not exceed 150 per cent of the service pressure ratings given above.

Sec. 3—Sizes

The sizes of the flanges in Tables 1, 2, and 3 are identified by the corresponding "nominal pipe size."

Sec. 4—Marking

When specified by the purchaser, flanges shall be steel stamped with the size, the name or trade mark of the manufacturer, the AWWA class as defined in Sec. 2 or, for Class E, the flanges may be marked as required for the 150-psi standard, ASA B16e, and the ASTM specification number and grade.

Sec. 5—Materials

5.1. *Ring Type Flanges.* Ring type flanges may be made either as forgings, or by being cut from plate or formed from bar and welded. Forgings shall at least comply with ASTM A181, Grade I. Plate and bar shall have a tensile strength not less than 50,000 psi nor more than 72,000 psi, a minimum yield point of 27,000 psi, a phosphorus maximum by ladle analysis of 0.04 per cent and by check analysis of 0.05 per cent, and a sulfur maximum by ladle analysis of 0.05 per cent and by check analysis of 0.063 per cent (ASTM A283, Grades B, C, or D will meet these requirements).

5.2. *Hub Type Flanges.* Hub type flanges shall be made either as seamless forgings or as welded bar rings. Forgings shall at least comply with ASTM A181, Grade I. Bar shall have a tensile strength not less than 50,000 psi nor more than 72,000 psi, a minimum yield point of 27,000 psi, a phosphorus maximum by ladle analysis of

0.04 per cent and by check analysis of 0.05 per cent, and a sulfur maximum by ladle analysis of 0.05 per cent and by check analysis of 0.063 per cent.

5.3. *Bolting.* Carbon steel bolts shall at least meet ASTM A-307, Grades A or B.

Sec. 6—Facing

Flanges of all classes shall be flat faced—that is, without projection or raised face. The dimensions given for thickness are minimum. The flanges shall be faced smooth or may have a serrated finish of approximately 32 serrations per inch, approximately $\frac{1}{64}$ in. deep. Serrations may be either spiral or concentric.

Sec. 7—Gaskets

These standards are predicated on the use of cloth-inserted rubber gaskets $\frac{1}{16}$ in. thick. The gasket shall extend from the inside diameter of the flange to at least the inside edge of the bolt holes, or it may extend beyond the bolt circle.

Sec. 8—Bolting

Drilling templates are in multiples of four so that fittings may be made to face in any quarter. Bolt holes shall straddle the center line, and shall be drilled $\frac{1}{8}$ in. larger in diameter than the nominal diameter of the bolt.

Bolts shall be of steel with American Standard Regular unfinished square or hexagon heads, and the nuts shall be of steel with American Standard Regular hexagonal dimensions, all as specified in American Standard for Wrench Head Bolts and Nuts and Wrench Openings (ASA B18.2).

All bolts and all nuts shall be threaded in accordance with American Standard for Screw Threads (ASA B1.1), Coarse-Thread Series, Class 2A and 2B fit.

Sec. 9—Tolerances

The dimensions listed in Tables 1, 2, and 3 are subject to the following tolerances:

Dimension	Tolerance
	in.
Inside diameter of flange	$+\frac{1}{16}-0$
Outside diameter of flange	$\pm\frac{1}{8}$
Thickness of flange	$+\frac{1}{8}-0$
Length through hub	$+\frac{3}{16}-\frac{1}{16}$
Bolt circle	$\pm\frac{1}{16}$

Sec. 10—Attachment of Flanges to Pipe

The attachment of the flanges to the pipe shall be made by means of two fillet welds of the size shown in Fig. 1.

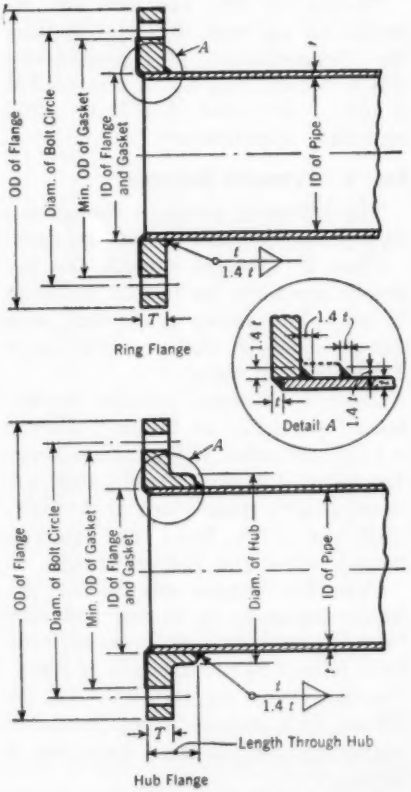
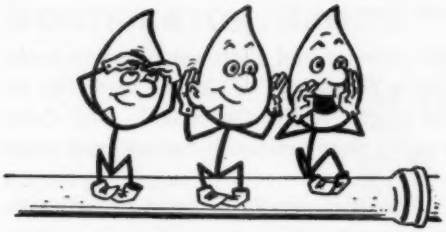


Fig. 1. Attachment of Flanges to Pipe
The flanges are attached to the pipe by means of two fillet welds.



Percolation and Runoff

Our worries are almost over. All we need do is wait for January 31 to roll around and, whether it's Adlai or Ike, he'll be committed to be good to us. If it's the Governor, his platform will call on him "to preserve the sources of priceless water" and, in working out programs for rational distribution of water in arid areas, to "aid in delivering this essential of life cheaply and abundantly." If it's the General, his platform will obligate him to see that "authorized water projects will go forward progressively with immediate priority for those in water shortage areas . . ." and that "efforts to undermine state control over water use" will be vigorously opposed. What if all this is purely planktonic? The very fact that drinking water is in the platform as well as on it for one of the national passionals is certainly more than a beginning. Actually, the step from "fit to be drunk" to "fit to be bunk" may be the biggest one in getting by our worries.

From the ridiculous to the sublime, the new appreciation of water appears equally as ardent. Thus, like politics, religion seems to have clambered aboard the water wagon. It was an article entitled "Water! Give Us Water!" featured in a recent issue of *"The Advent Review and Sabbath Herald,"* general church paper of the Seventh-Day Adventists, that gave us a true clue to the situation. There, in a discussion of the water shortage problem as it plagues most of Africa, it was pointed out:

> There is no better morale booster at our missions than the existence of an adequate water system and supply, and nearly every station and institution needs this help. Here is a golden opportunity to assist in improving the health and efficiency of our missionaries and native workers in this needy part of the great African mission field.

All of which should certainly qualify water as a spirituous liquor.

Speaking of water's powers, as we have not only just been but always are, some suburban first-hand experiences with same have convinced us

(Continued on page 2)

(*Continued from page 1*)

that water utilities ought to imitate industry and distribute direction booklets with their product. What if the "How to Use" looked more like an encyclopedia than a recipe? The bigger, really, the better! And every suggested use could be not only a pretty penny earned but a customer saved from two fates worse than death.

To him to whom the task will now undoubtedly be assigned forthwith, we can recommend two authoritative water entries, unconditionally guaranteed to make the meters tick:

SKUNKS in garage behind oil cans in corner, getting rid of without getting close to, by use of, through garden hose.

WASPS nesting at joint of gutter and downspout when house is being painted, getting rid of without getting close to, by use of, through garden hose.

When human suffering can be so simply washed away, it would be downright sadistic and unbusinesslike of water works executives not to give their customers the word. In the interim, of course, P&R columns will be open to all entries.

The flowering of water supply art appears to be at hand, what with a drinking fountain in the form of an orchid and a lawn sprinkler that looks like a blossom in a flower pot. First of these is an "assault on convention" by Spanish artist Jōan Junyer, which was exhibited recently at the New York Museum of Modern Art. Eight feet high, painted with flowing petals and a stippled yellow, blue, and white enamel finish, this cataract in abstract features two spouts—one at junior, the other at Junyer level. Feeling that "water is such a nice thing, it should be treated nicely," the artist took four bathtubs and cut, welded, and enameled them into his "nonstylized" fountain. Nonsomethingelse is the pot put out by Emenee Industries, Inc., of New York City. Made of plastic with a blossom that revolves to throw a spray to distances of 20 ft, the pot presumably represents naturalism in design. Of course, if you prefer inconspicuous recognizability to awkward orchids and peripatetic petunias, why that's your business—thank goodness!

With floral art in, though, flooral art appears on its way out. At any rate, those paintings by Diego Rivera on the floor of the aqueduct at the new Mexico City Water Works (April P&R p. 12) are fast fading away in spite of polystyrene in the pigments and a coating of rubber. And if, as Diego claims, "it is because of the bad quality of the water, which contains mud, crude oil, and tar," we imagine Mexico Citians prefer a trace of Rivera's artistry in a good glass of water to a whole gallery of him unpalatable.

(*Continued on page 4*)

WORTHINGTON-GAMON

WATCH DOG WATER METERS

The meter used by thousands of municipalities in the U. S.



"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER DIVISION

Worthington Corporation

296 SOUTH STREET, NEWARK 5, NEW JERSEY

OFFICES IN ALL PRINCIPAL CITIES

(*Continued from page 2*)

Fluoridata of current interest include: the report by the American Dental Assn. last month that more than 25,000,000 people in 656 communities in the U.S. will be drinking fluoridated water by the end of 1952; the estimate that 700,000,000 dental fillings a year are required to restore American mouths to healthy condition, including 280,000,000 in the mouths of children between 6 and 18; the fact that a mere 20 cents will get you a whole half-gallon of Hinckley & Schmitt's delicious drinking water, containing both minerals and *natural* fluorine. Pretty hard to bottle it up now!

Meredith E. Johnson, New Jersey state geologist, suffered severe burns and Henry Herpers, a geologist on his staff, was killed instantly, as the result of an accidental encounter on July 11 with a storm-downed high-tension wire. The two geologists were making their way through heavy underbrush to an abandoned limestone quarry near the Delaware Water Gap to study rock formations when the tragic accident occurred. At last reports, Johnson was still undergoing treatment for his injuries at Monroe County Hospital, East Stroudsburg, Pa.

(*Continued on page 6*)



M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

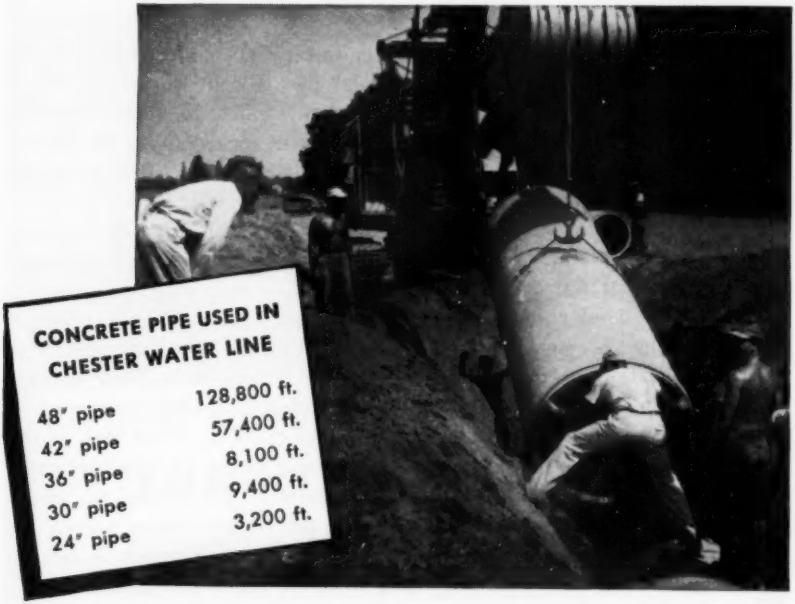
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On Request

JOSEPH G. POLLARD CO., INC.

Pipe Line Equipment

New Hyde Park **New York**



Chester, Pa. Boosts Water Supply with 39-Mile Line of CONCRETE PIPE

To obtain adequate water for increased needs the Chester, Pa. Municipal Authority built a 39-mile concrete pipe line from a dam on Octorara Creek. Pipe sizes and quantities used are shown in the box. The engineers were Albright & Friel, Inc. of Philadelphia. The general contractor was the Berlanti Construction Company, Inc. of Harrison, N.Y.

Whether the water line you plan is long or short concrete pipe offers the rugged strength, long life and economy so necessary for satisfactory service. Tuberculation never occurs to impair hydraulic efficiency. Its tight joints and uniformly dense structure prevent leakage and infiltration.

Concrete pipe is clean and *stays* clean, thus minimizing taste, odor and dirty water difficulties. It meets all operating requirements, gives long years of ***low-annual-cost*** service.

PORTLAND CEMENT ASSOCIATION
33 W. Grand Ave. / Chicago 10, Ill. \ A national organization to improve and extend the uses of portland cement and concrete through scientific research and engineering field work

(Continued from page 4)

The newest profession must be the one we encountered in a recent advertisement of "commode repair specials" by a Florida plumbing supply house. "Toileteer consultant" is the term applied to their "eminent flushologist" Harry L. Daugherty, whose job it apparently is to counsel customers as he waits on them. His slogan: "If water runs through it, we have it."

More than mere toileteer, though, must be Carl F. Boester, engineer and housing consultant for the Purdue Research Foundation, who recently made a toilet that was practically self-sufficient—eliminating the need for septic tank, cesspool, chemicals, or hookup with the water supply. Not an outhouse either, Boester's toiletechnology has turned out what amounts to a new application of the garbage grinder in a closed disposal system. Water is included, of course, but only 60 gal of it in a tank from which it is pumped into the toilet with enough force to cause an inner wall of the fixture to spin at about 800 rpm. The spinning draws air into the water as well as causing the toilet to grind up any solids. The ground up waste, air, and water then flow to the tank, where the oxygen causes almost instant decomposition, converting the waste matter to gas which is carried off through a tiny outlet pipe projecting from the top of the tank outdoors. Efficiency of the oxidation is so great that only about $\frac{3}{4}$ lb of insoluble ash per person per year accumulates at the bottom of the tank. Cost of operation is approximately $2 per month for power to keep the $\frac{1}{8}$-hp electric motor running continually.

In saving 6 to 7 gal of water per flush as well as the septic tank and tile field problem, the device ought to earn Boester the undying gratitude at least of farmers and owners of nonconvenienced summer cottages. No more Chic Sale, but better—Boester!

William J. Kingsley has been appointed assistant general sales manager of the Carborundum Co. of Niagara Falls, N.Y.

(Continued on page 8)

Loose-Leaf **BINDERS**
for A.W.W.A. Standards
Price $2.50
AMERICAN WATER WORKS ASSOCIATION
521 Fifth Ave. New York 17, N.Y.

Sturdily bound in blue canvas with lettered backbone, the binder has durable metal hinges, capacious 1½-in. rings and eight blank separator cards with projecting tabs. All A.W.W.A. specifications are being provided with marginal holes drilled to fit the binder.


NEW TOOL FOR WATER WORKS
PITMAN HYDRA-LIFT
versatile inexpensive truck crane
Especially developed for handling pipe, the new Pitman Hydra-Lift uses hydraulic power to swing boom 180 degrees, lift boom 100 degrees. Boom telescopes from 12 to 22 feet. Lifting capacity is 6,400 pounds; requires only 40 inches behind the truck cab, leaving bed free for normal truck purposes. Moves from job to job at normal truck speeds. Hydra-Lift comes ready to install on the frame of any truck; two-ton truck or larger recommended. Write today for complete information on the new Pitman Hydra-Lift!
PITMAN MANUFACTURING COMPANY
300 WEST 79TH TERRACE
KANSAS CITY, MISSOURI

(Continued from page 6)

Open season on phreatophytes was invoked last month by Interior Secretary Oscar Chapman, with the announcement that they were stealing an annual 20,000,000 to 25,000,000 acre-ft of precious water from the drought-ridden Southwest. Back of the announcement was a comprehensive report on the subject just completed by the U.S. Geological Survey, which also pointed out that phreatophyte wastage involved a 16,000,000-acre area in 17 Western states and was largely reclaimable by their destruction and replacement by plants of high economic value. Oh yes, phreatophytes are plants—such useless ones as the alder, arrowweed, batamote, cottonwood, mesquite, rabbitbrush, willow, big breasewood, and salt cedar, which lift large amounts of ground water, sometimes from great depths, and dissipate it as vapor to the atmosphere. It is such consumptive waste by plants that is said to represent the largest source of reclaimable water in the area. Whoa, though, phreatophyters, stay 'way from that alfalfa, which, though a common type, is worth its weight in water.

Robert J. Sweitzer has joined the home office sales staff of Lock Joint Pipe Co., East Orange, N.J.

(Continued on page 10)



6 Reasons why
PALMER SURFACE WASH SYSTEMS
are specified by water works engineers

1. Prevent Sand Beds From Cracking.
2. Eliminate Mud Balls.
3. Save Wash Water.
4. Lengthen Filter Runs.
5. Higher Rates of Filtration.
6. Better Tasting Water.

Write today for Bulletin 451 and a list of water purification plants that have gone modern.

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AMONG WATER WORKS MEN

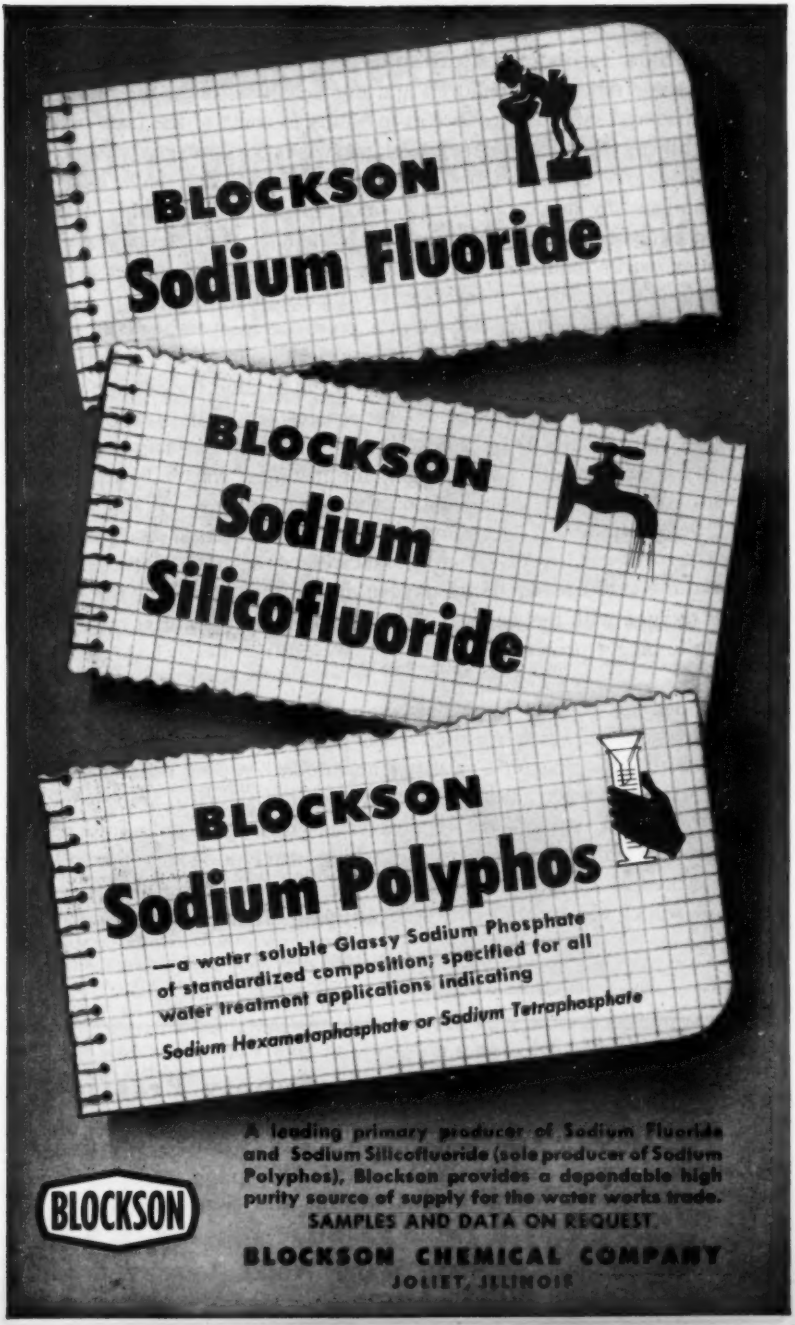


THE HEAVY-DUTY ELLIS PIPE CUTTER IS *BEST*
FOR CUTTING LARGE SIZES OF PIPE

No. 01 Cuts Pipe 4" to 8"
No. 1 Cuts Pipe 4" to 12"

Write for circular and price list No. 35J, on our complete line of pipe cutting tools.

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BLOCKSON
Sodium Fluoride
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Sodium
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Sodium Polyphos
—a water soluble Glassy Sodium Phosphate of standardized composition; specified for all water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride and Sodium Silicofluoride (sole producer of Sodium Polyphos), Blockson provides a dependable high purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST.
BLOCKSON
BLOCKSON CHEMICAL COMPANY
JOLIET, ILLINOIS

(Continued from page 8)

Asteroids rather than adenoids are leaving our children open-mouthed these days—our children and our scientists both, for finally it is being considered safe to introduce even adults to some of the facts of space. Actually all the dangers of space travel, such as lack of oxygen, cosmic radiation, 500-degree heat, meteors, and weightlessness, that have long since been conquered by our comic strip cosmographers, will probably delay the first live expedition for many years. Meanwhile, there seems no reason why water works men need be as stuffy as the physicists about accepting the solutions that junior's mentors have already provided.

Water, science tells us, will be at a premium in space, presumably because of the lack of oxygen. And in the weightless regions everything will float, so that water will have to be drunk on the fly, and the sewage problem will be one of power ejection to get the wastes out of the traveler's orbit. But these matters are mere child's play! In his recent trip to Jupiter's Moon 10, Tom Corbett, *Space Cadet,* for instance, wasn't bothered a bit by them. Weightlessness? Turn on the gravity plates. Water and oxygen at the destination? Turn on the hydrogenerator—a machine which "takes the rocks and dirt of Moon 10 and changes the atomic structure, turning the atoms into hydrogen and oxygen atoms, then combines the two and releases oxygen with the water." You'll pardon us if we blast off now and jet along to bigger problems.

Science isn't all up in the air these days, though. Some portion of it is right here on earth making noise—noiseless noise, in fact, that is credited with killing bacteria in water and milk, blending oil and water or even mercury and water, clearing up fog, relieving arthritis, aging wine and whisky overnight, stimulating the bacteria which turn milk into cheese, disintegrating gallstones, agitating washing machine water much better than mechanical methods, stimulating the growth of vegetables, curing sprained ankles of Parisian dancers, purifying the air, detecting flaws in

(Continued on page 12)

Back in stock!

Manual of British Water Supply Practice

Compiled by the Institution of Water Engineers, London

The essence of the water supply art, as practiced in Great Britain, is well documented in this 900-page compilation. Generously supplied with illustrations and reference lists.

Price $7.50

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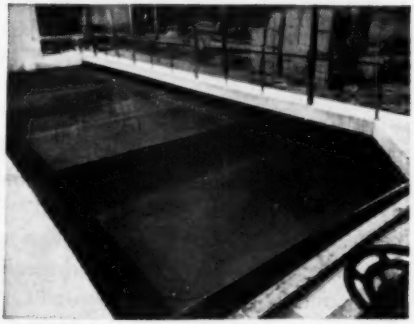
modernize—for greater capacity—economically with Rex Floctrol and Verti-Flo!

When increased demands exceed the capacity of your water treatment plant, you can bring your plant up-to-date . . . step up capacity . . . economically with **REX FLOCTROLS** and **VERTI-FLO** Clarifiers. Installed in new or existing tanks, these efficient units provide greatly increased capacities . . . more effective results.

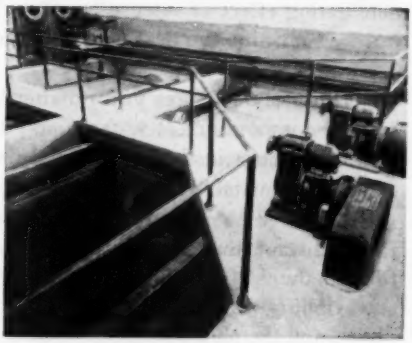
At the Fairmont, Minn., treatment plant, for example, **REX FLOCTROLS**, installed in modernized tanks, and a **VERTI-FLO** in an existing tank, made possible an increase in plant capacity from the originally designed capacity of 500,000 G.P.D. to 2,000,000 G.P.D. *without increasing the physical size of the plant.*

Tests show that the chemical reaction is complete within the **FLOCTROL** despite the extreme seasonal changes in water temperature.

The **VERTI-FLO** equipment was installed in two existing rectangular settling tanks, providing for and efficiently handling 2,000,000 gallons daily, an increase of 1,500,000 gallons daily over the original designed capacity of the two conventional tanks. Detention time was reduced from 6.2 hours to 1½ hours, and solid removals were remarkably improved. Effluents were improved to the point where filter runs were increased 5 to 6 times.



REX VERTI-FLO Clarifier at Fairmont, Minn.



REX FLOCTROLS at Fairmont, Minn.

G. E. Basom, Manager, Water and Light Commission, Fairmont, Minnesota

Why not reap the benefits of this modernization for your plant? For complete details and informative literature, write: **CHAIN BELT COMPANY, 4609 W. Greenfield Ave., Milwaukee 1, Wisconsin.**

CHAIN BELT REX COMPANY

WATER TREATMENT EQUIPMENT

(Continued from page 10)

both metals and men, and a thousand other things, including, of course, calling your dog. Unless you really want your dog badly, you probably won't want to spend the $1,000 that a home-size ultrasonic generator costs these days, but since they're also guaranteed to do a good job of mixing both cocktails and cake batter, they'd be a cinch at $999.90. Without much question, research now being carried out will lead to some basic application of supersonics to water purification as well as to a host of other tasks which it can perform better than present equipment. At home, however, it may be well not to throw your "Handy-Dandy 16-Way Can Opener and Kitchen Tool" quite yet.

Wetter water, next to noiseless noise, may seem a sort of pint-size panacea, but things are looking up. Already well known for their performance in fire fighting fluid, in removal of metals from ore by flotation, in cleansing agents such as "First" for floors, and in various industrial processes where water surface tension causes trouble, the wetting agents are now being eyed as an aid to medicine. By the use of wetter water in the humidifier bottle in a croup tent, it has been found possible to produce more intense moisture in the air, which helps infants recover from such respiratory infections as laryngeal diphtheria. Remembering too well the debilitating effect of intense humidity here in New York last summer, we can well imagine the next step—wetter water a weapon of war!

Philately will get you nowhere, but it may offer the opportunity to bring the importance of water supply to the attention of every stamp licker and letter getter in the country and then some. What we're driving at, of course, is philately's fostering of the commemorative stamp and the imminence of AWWA's 75th birthday. Although March 29, 1956, may seem rather distant imminence, it appears from the experience of such organizations as the ASCE and AAA, both recent commemorees, that it is none too soon right now to get into motion, at least to ask the philatelists, the philatephiles, and the philaterers among us to stand up and be counted—in, that is. Just address Phil at P&R.

Arthur J. Simpson, principal assistant engineer of the Newark, N.J., Water Div., has been appointed division engineer, succeeding William G. Banks, retired. The new principal assistant engineer is Laurie M. Leedom, formerly construction engineer for the division.

Frank N. Speller, author of *Corrosion: Causes and Prevention,* has joined the firm of Management Counselors, Inc., business consultants of New York.

(Continued on page 14)



● It isn't necessary to specify over-sized pipe for your large-diameter water lines to meet anticipated "shrinkage" in flow capacity due to tuberculation.

It's far less expensive to *prevent tuberculation* by coating the pipe interior with a smooth, spun lining of Bitumastic® 70-B Enamel. Then you can select pipe size solely on the basis of desired capacity.

Bitumastic gives you a lastingly-high coefficient of flow that reduces pumping costs . . . results in savings that more than pay the cost of the lining.

Bitumastic 70-B Enamel also makes it unnecessary for you to specify additional wall thickness to compensate for corrosion. An exterior coating of Bitumastic 70-B Enamel, combined with the spun lining, forms a barrier against all types of corrosion, inside the pipe and out.

Make certain your community is getting its money's worth of proper protection—specify Bitumastic 70-B Enamel for your large-diameter lines.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC., Tar Products Division, Dept. 1005T, Pittsburgh 19, Pa.

District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh, and Woodward, Alabama

(Continued from page 12)

Roger W. Armstrong, consultant and former chief engineer of the New York City Board of Water Supply, died on August 24, after a long illness, at the age of 72. He had served the system for 46 years, except for an interval of military and overseas service during and immediately after World War I.

Franklin Thomas, professor of civil engineering and dean of students at California Institute of Technology, died on August 27 after an illness of several weeks. He had joined the faculty in 1913 to develop the civil engineering department, became a division chairman in 1924, and 20 years later became dean of students. Always active in professional and community affairs, he was a member and chairman of the Colorado River Board of California and was instrumental in bringing Colorado River to southern California. He was also a member and for many years was vice-chairman of the board of the Metropolitan Water Dist. of Southern California.

Alfred Crew, formerly associated with the engineering firm of Havens & Emerson, has opened his own consulting office at 154 Linden St., Ridgewood, N.J.

(Continued on page 16)

THE AMERICAN AGRICULTURAL CHEMICAL COMPANY · AA QUALITY

For Public Water Fluoridation

Sodium Silicofluoride—98%

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Sodium Fluoride—97%

(Dense Powder or Granular)

White or tinted blue

Minimum of dust in handling

Minimum of storage space

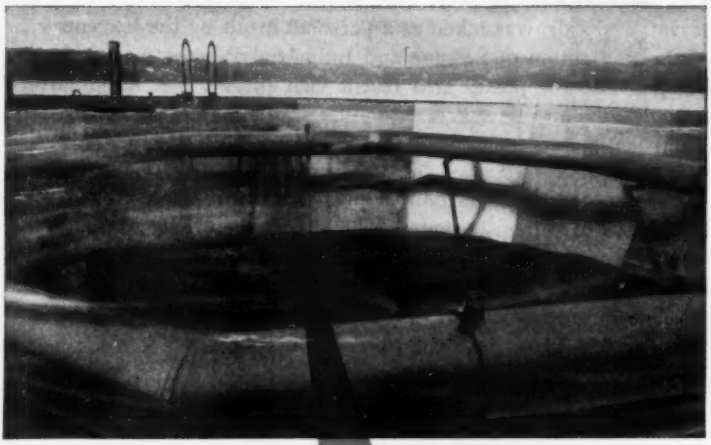
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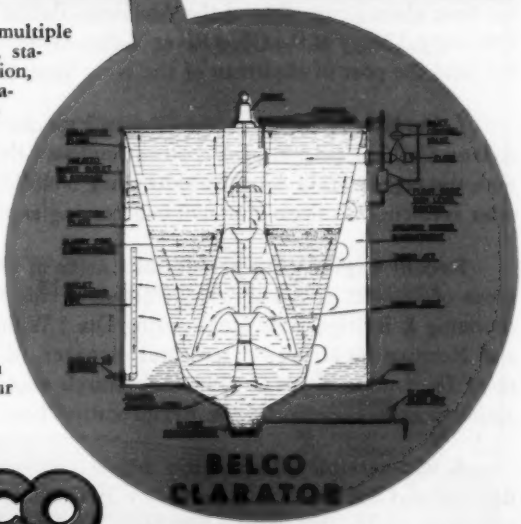
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PROCESSES FOR REMOVAL OF WATER IMPURITIES



The Clarator has multiple uses — clarification, stabilization, neutralization, chlorination, purification, alkalinity reduction, softening, silica removal, iron removal, controlled conditioning. The type and quantities of the chemicals used determine the final quality of the treated liquid effluent. Complete description and illustrations in Bulletin 108. Write for your copy.



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Belco Industrial Equipment Division, Inc.

PATERSON 3, NEW JERSEY

OUR REPRESENTATIVES LISTED IN THOMAS REGISTER

(*Continued from page 14*)

Like to winter in Florida? Here's your chance! One of the principal water works systems in that winterful state is actually looking for a qualified sanitary engineer for a permanent position. Thus, for a tan and career that will be the envy of your friends, drop a line right now to P&R Vacation-Vocation Dept. at AWWA headquarters.

"Use Water Wisely," the slogan which appears on AWWA's conservation decals, was taken as a personal insult by the Executive Secretary of the Federation of Sewage and Industrial Wastes Associations when he bumped into the poster at a recent visit to AWWA headquarters. Well enough known to be addressed by his first name, he was assured that if the insult had been intended it would have read "Use Water for Pete's Sake!"

That news makes names make news is being proved in Texas in these days of water shortage. Thus, when the San Antonio Chamber of Commerce set up its water conservation committee, it had no choice but to appoint member Frank Drought as chairman—not to live his name down, perhaps, but to work it off. And at Bryan, the wedding of Miss Betye Rainwater to Mr. Clinton Fawcett was hailed as a move in the right direction. What price water?

Allan H. Rogers, public works superintendent at Garden City, N.Y., has been elected president of the American Public Works Assn., succeeding Edward J. Cleary of the Ohio River Valley Water Sanitation Com. Rogers has held the post of chairman of the New York section of AWWA.

L. A. Elsener, manager of the San Francisco office of Chicago Bridge & Iron Co., has been elected a vice-president of the firm. His association with the organization dates back 30 years to 1922, when he joined the staff after receiving his degree in civil engineering from Purdue University.

Recent engineering promotions made at Worthington Corp. include those of John E. Lancaster, made assistant chief engineer of the Air Conditioning & Refrigeration Engineering Div.; William C. Osborne, manager, and Norman L. Meyerson, assistant manager, of the Research & Development Dept.; Frederick C. Gilman, research engineer; and T. A. Herman, assistant chief engineer of the Reciprocating Engineering Div.

A submersible sump pump that dispenses with the usual protruding float or rod has been announced by Fairbanks, Morse & Co. Intended primarily as a cellar drainer for home owners, the unit is designed to be installed in a 16-in. or deeper sump, with only the electrical cable and discharge piping extending above the floor level.

(*Continued on page 20*)

Short story of...



...A LONGER LIFE

In 1943, a small New England town was faced with the problem of replacing a condemned 57 year old water tank. Serious leaks had begun to develop in 1935, and had continued despite applications of various coatings over a period of 8 years. It was finally decided to replace the tank because of its leak record, though the cost was high.

It was then that the Electro Rust-Proofing engineer was called in. After careful examination of the entire structure, he recommended that cathodic protection equipment be installed at a fraction of the tank's replacement cost.

Since then, no further leaks have been observed, and it is felt that the tank, protected by Electro Rust-Proofing cathodic protection, may be kept in operation indefinitely.

Why not give *your* buried or submerged metal structure a longer life? A letter today may save your tank tomorrow.

COMPLETE CATHODIC PROTECTION SERVICE • DESIGN ENGINEERING MAINTENANCE INSTALLATION EQUIPMENT

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REPRESENTED IN PRINCIPAL CITIES IN THE UNITED STATES

Over 15 years of Cathodic Protection Engineering, Research and Development


This is the pipe
IRON
Courtney Allen

that's known as the

Taxpayers' Friend

To a tax-burdened public the statement that cast iron pipe is the "taxpayers' friend" is more than a mere figure of speech. To most waterworks engineers it is a cold fact. They know that cast iron pipe in water distribution systems has saved, and continues to save, millions of dollars in local taxes.

The useful life of cast iron pipe is known to be 4 to 5 times the average term of a water revenue bond issue. More than 35 American cities have cast iron mains in service that were installed over 100 years ago. A survey sponsored by three waterworks associations shows that 96% of all six-inch and larger cast iron pipe *ever laid* in 25 representative cities, is still in service.



Fortunately for taxpayers, over 95% of the pipe in America's water distribution systems is long-lived cast iron pipe—*the taxpayers' friend.*

This cast iron water main installed in Richmond, Virginia, 120 years ago, is still in service. Over 35 other cities have century-old cast iron mains in service.



CAST IRON PIPE

America's No. 1 Tax Saver

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CAST IRON PIPE RESEARCH ASSOCIATION, THOS. F. WOLFE, MANAGING DIRECTOR, 122 SO. MICHIGAN AVE., CHICAGO 3.

(*Continued from page 16*)

Infinity was the distance from the Dodgers to the Giants until 1949, when Manager Leo Durocher bridged it. The distance from California to Florida, meanwhile, remained at infinity plus 3,000 miles. But now that standard, too, has succumbed to the span of another glutton for punishment, Secretary Bill Aultman of the California Section 1950–51, and, having moved, of the Florida Section now in 1952. Happy difference for AWWA is that Bill doesn't feel the necessity of reestablishing the standard.

A shillelagh for a dowsing rod must be the secret of James Harte of Clonakilty, Eire, whose advertisement in the Cork *Examiner* last August offered his "professional" services as water diviner. How else, indeed, could he hope to compete in magic with the elves, gnomes, and leprechauns who populate and prosper all Ireland. And a changed land it must be, too, to even want water.

A. J. Gates, formerly assistant city engineer of Wichita Falls, Tex., and superintendent of the community's water department, has been appointed southwestern representative of Pipe Linings, Inc., of Los Angeles.

On tap:

WATER QUALITY & TREATMENT

Second Edition—Revised and Enlarged

AWWA's manual of *Water Quality and Treatment* brought up to date, with chapters on: source characteristics; aquatic organisms, quality standards, stream pollution and self-purification, impounding reservoir control, aeration, coagulation, mixing and sedimentation basins, disinfection, taste and odor control, filtration, scale and corrosion control, softening, iron and manganese removal, boiler water treatment, fluoridation, and treatment plant control. With four appendixes and an index, that makes 451 pages.

Price: For general sales, $5.00. For AWWA members sending cash with order, $4.00

AMERICAN WATER WORKS ASSOCIATION
521 Fifth Avenue New York 17, N.Y.



1 REGULAR CALMET DOES THE WORK OF 2

A regular size 1½-inch or 2-inch CALMET WATER METER will do the work of a corresponding size compound meter, do it better and at less cost.

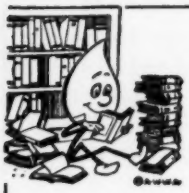
HERE IS WHY:

1. The CALMET sells for much less than a compound meter.
2. The CALMET insures better revenue because it is more consistently accurate.
3. Because of CALMET'S simplicity it costs less for repairs, maintains its accuracy longer.

● *SALES REPRESENTATIVES—Write for complete details of the CALMET franchise in your territory.*

CALMET WATER METERS

MADE BY WELL MACHINERY & SUPPLY CO., INC.—FORT WORTH, TEXAS



The Reading Meter

Handbook of Applied Hydraulics. *Calvin Victor Davis, ed. McGraw-Hill Book Co., New York (2nd ed.; 1952) 1,272 pp.; $15*

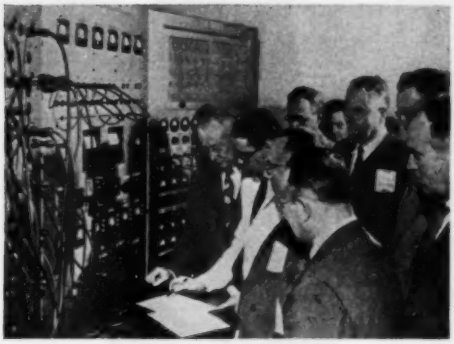
The humor in retaining the appellation "handbook" for tomes of this weight is becoming—if we may abuse the metaphor further—a little heavy-handed, but the volume is otherwise a serious reference work of commanding respectability. The list of contributors includes such familiar names as Thomas R. Camp, Samuel A. Greeley, Julian Hinds, and William E. Stanley. New chapters on water hammer, surge tanks, and other matters have been added since the appearance of the first edition in 1942, and other sections have been rewritten or revised. The use of examples from the design of actual projects lends authenticity to the illustrations, but also makes some of them hard to read, particularly in the size in which they must be reproduced. In addition to the chapters on various aspects of dam design, sections of especial value to water suppliers include those on flumes, tunnels, and pipelines; pumps ("hydraulic machinery"); water supply, distribution, and treatment itself; and hydrology. Algebraic and graphic methods of solving flow problems are presented in the appendixes.

New England Drainage Basins: *Summary report on water pollution. Water Pollution Series, No. 7; Public Health Service Pub. No. 88; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 148 pp.; paperbound; free*

The New England states, at once picturesque and highly industrialized, exploit both of these characteristics to maintain an economy in which manufacturing and recreation are dominant, and equally dependent upon the region's water supplies. The report indicates the need for considerable work in pollution abatement, not only by municipalities and industries, but also by private individuals whose private sewers, storm drains, and septic tank outlets contribute to the problem. It is also suggested that state enforcement agencies be given more adequate funds and staffs, and that the state of Maine enact legislation establishing such an agency.

(Continued on page 86)

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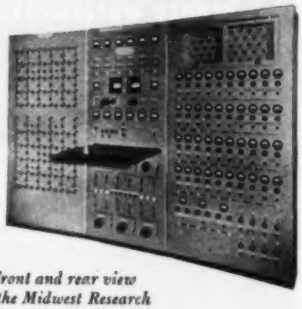
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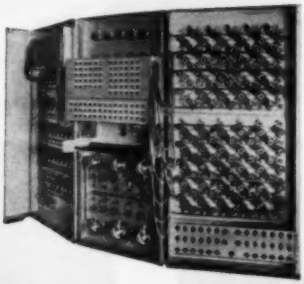
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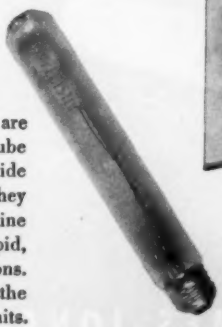
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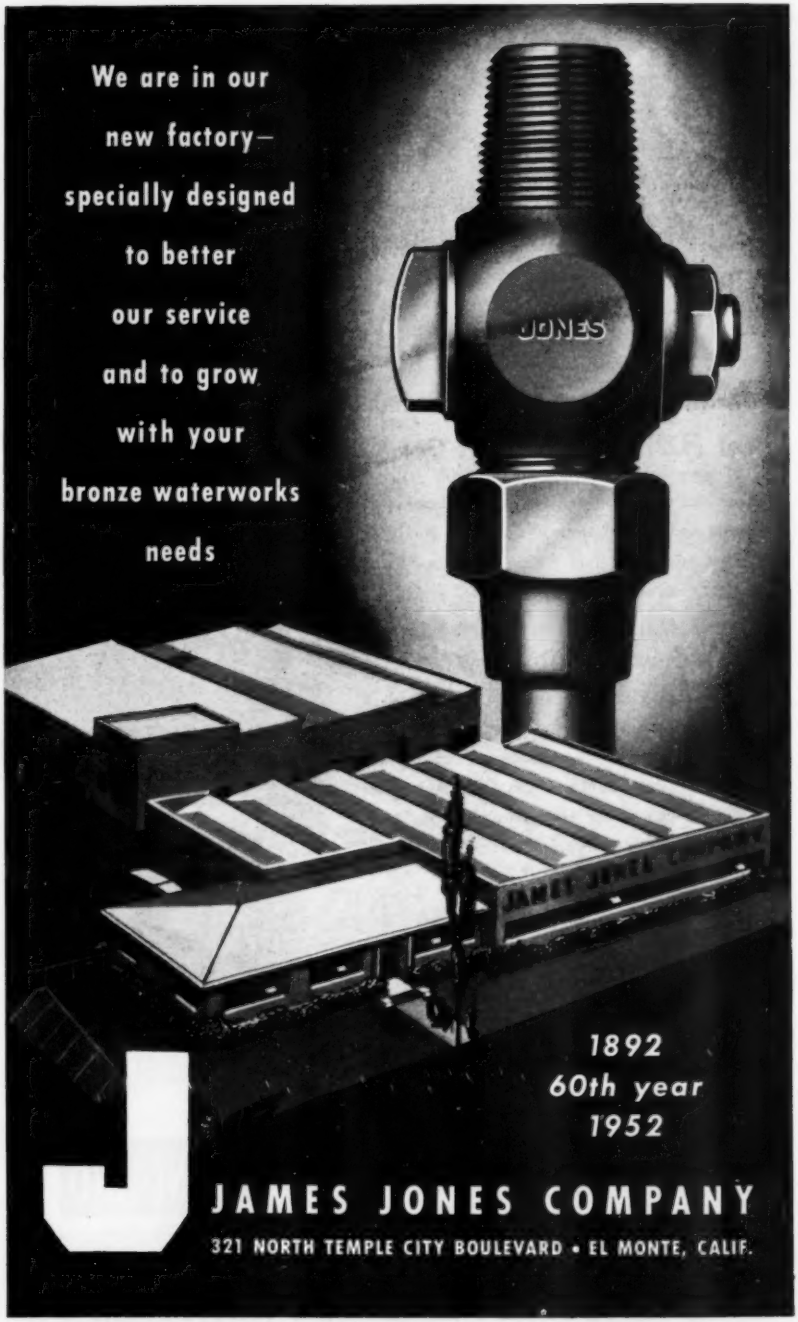


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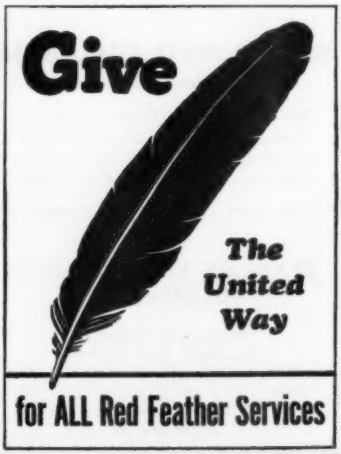
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(*Continued from page 32*)

Roller, David, Chem. Engr., Freeport Sulphur Co., Drawer A, Freeport, Tex. (July '52) *P*

Romero Alvarez, Humberto R., Chief of Designer Engrs., Secretaria de Recursos Hidraulicos, Fundidora de Monterrey 89, Mexico 14, D.F., Mexico (July '52) *MP*

Roose, H. Louis, Project Engr., Water Dept., City Hall, Kansas City, Mo. (July '52) *M*

Rosson, Harrell B., Graduate Student & Water Plant Operator, Water System Service, Oklahoma A & M College, Stillwater, Okla. (Jr. M. July '52) *P*

Schaedle, Robert C., Supt. & Treas., Pine Hill Water Co., 156-10—32nd Ave., Flushing, N.Y. (July '52)

Schmidt, George G., Asst. Engr., Div. of Water, Dept. of Public Works, 101 City Hall Annex, Newark, N.J. (July '52) *M*

Schroyer, Charles B., First Operator, Verona Pumping Div., Battle Creek, Mich. (July '52) *M*

Schueler, Russell John, Operator, Pumping Div., Battle Creek, Mich. (July '52) ***M***

Sears, Homer T., Sales Repr., Hersey Mfg. Co., 512 Hass-Howell Bldg., Atlanta, Ga. (July '52)

Simpson, Arthur J., Div. Engr., Div. of Water, 101 City Hall Annex, Newark 2, N.J. (July '52) *MRP*

Sisson, Walker Hudson, Constr. Engr., The Upjohn Co., Portage Rd., Kalamazoo, Mich. (July '52) *MRP*

Sommer, Franklin L., Sales Engr., Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia 42, Pa. (July '52)

States, James Henry, Design Engr., The Chester Engrs., 210 E. Parkway, Pittsburgh 12, Pa. (July '52) *MP*

Steel & Tank Service Co., Thomas V. Altizer, Gen. Mgr., 118 W. 24th St., Charlotte, N.C. (Assoc. M. July '52)

Steeper, Robert E., Sales Development, Hercules Powder Co., Delaware Trust Bldg., Wilmington, Del. (July '52) *MP*

Stevens, Neil C., Operator, Verona Pumping Station, Battle Creek, Mich. (July '52) *M*

Stookey, Robert L.; *see* Portland (Ind.) Munic. Water Plant

Stroud, Henry Brannen, Water Plant Supervisor, Box 2208, Sarasota, Fla. (July '52) *M*

Suk, William J., Dist. Mgr., The Clark Controller Co., 205 S. 32nd St., Birmingham, Ala. (July '52) *RP*

Train, G. F., Water Supt., 529 E. 4th St., Superior, Neb. (July '52)

Uhrig, William E., Supt. of Utilities, 1899 Reading Rd., Reading, Ohio (July '52)

Vliet, Russell P.; *see* Hackettstown (N.J.) Board of Water Comrs.

Wait, Leo W., Supt., Wilber, Neb. (July '52) *M*

Walter, Lee Roy H., San. Engr., Div. of Sanitation, State Board of Health, Lawrence, Kan. (July '52) *MP*

Washburn, Carlyle, Supt., Del Este Water Co., 720—10th St., Modesto, Calif. Calif. (July '52) *M*

Watrous, John H., Dist. Mgr., Keasbey & Mattison Co., 391 Sutter St., San Francisco, Calif. (July '52) *M*

Wells Public Utilities Com., Howard E. Barton, Supt., Wells, Minn. (Munic. Sv. Sub. July '52)

Wilson, Robert A., Dist. Foreman, Tide Water Associated Oil Co., Box 243, Robinson, Ill. (July '52) *RP*

REINSTATEMENTS

Connolly, Joel I., 54 W. Hubbard St., Chicago 10, Ill. (June '30)

Crafton, Logan, Supt., Water Works, 122 W. 4th St., Bloomington, Ind. (Jan. '40)

Hartford Rayon Corp., Harold B. Mallett, Plant Engr., Rocky Hill, Conn. (Corp. M. Oct. '48)

Mallett, Harold B.; *see* Hartford Rayon Corp.

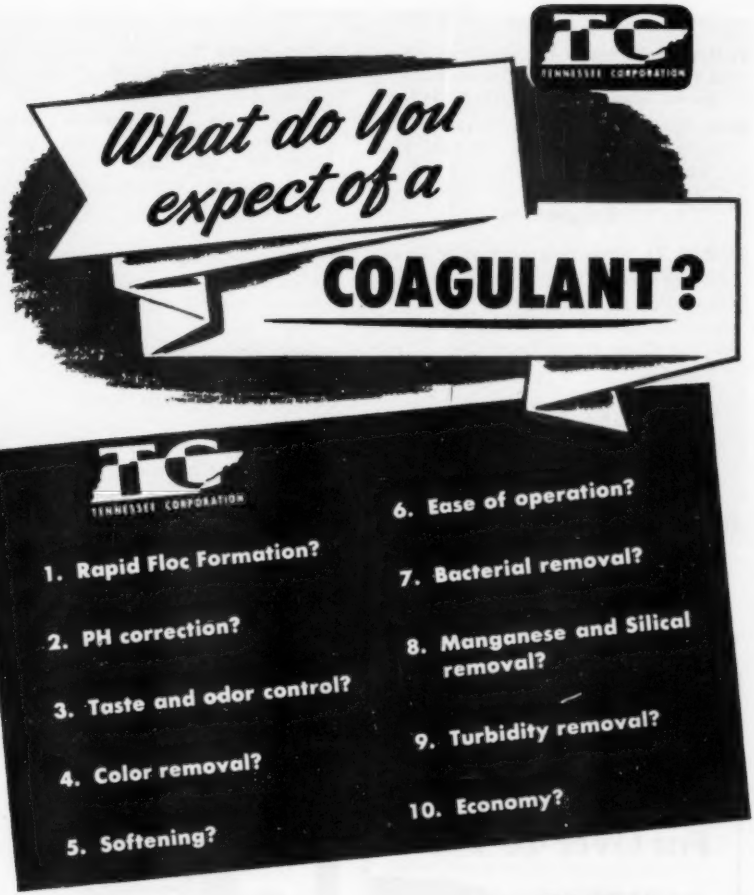
Turner, Samuel F., Cons. Ground-Water Geologist, 4046 N. 4th St., Phoenix, Ariz. (Jan. '49)

LOSSES

Deaths

Armstrong, Roger W., Cons. Engr., Board of Water Supply, 120 Wall St., New York 5, N.Y. (Apr. '16) *R*

(*Continued on page 36*)



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(*Continued from page 34*)

DeBerard, Emmons W., Resident Officer in Charge of Constr., Naval Training Center, Great Lakes, Ill. (Oct. '41) *M*

Hall, H. F., Chief Engr., Water Works Dept., Northern Apts., Sarnia, Ont. (June '20)

Resignations

Hall, G. D., Owner, G. D. Hall & Assoc., Larson Bldg., Yakima, Wash. (Jan. '36)

Haney, John H., Power Engr., E. I. du Pont de Nemours & Co., Inc., Chambers Works Plant, Penns Grove, N.J. (July '51) *MP*

CHANGES IN ADDRESS

Changes received between August 5 and September 5, 1952

Alderwood Water Dist., P. S. Lindbloom, Supt., Alderwood Manor, Wash. (Munic. Sv. Sub. Apr. '51)

Badley, Harry W., Repr., Neptune Meter Co., 119 W. Cloud St., Salina, Kan. (May '28) *Fuller Award '48.*

Badley, Willis H., Salesman, Neptune Meter Co., 1700—15th St., Denver, Colo. (Oct. '51) *MR*

Baker, Frank W., Sales Repr., R. D. Wood Co., 1058 Nichols Dr., Raleigh, N.C. (Jan. '50)

Baltimore County Metropolitan Dist., Charles B. Wheeler, Chief Engr., Court House, Towson 4, Md. (Corp. M. Oct. '44)

Brown, Horace A., 2450 N. Court Rd., Ottumwa, Iowa (June '11)

Bush, Paul J.; *see* Iola (Kan.) City Water Works

Chanute, City of, Paschal Grimes, City Engr., Chanute, Kan. (Corp. M. Oct. '51)

Colonial Heights, City of, C. C. Townes, City Engr., Colonial Heights, Va. (Corp. M. Apr. '48)

(*Continued on page 38*)

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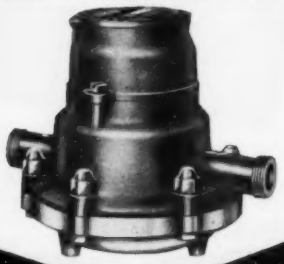
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(*Continued from page 36*)

Duggan, M. L., Mathieson Chemical Corp., 112 S. Tryson St., Charlotte 2, N.C. (Oct. '51)

Dunn, William Carey, 511 Scales St., Starkville, Miss. (Apr. '19)

Ford, George A., Pres., Fairfax Hydraulics Water Co., 132 N. Kings Highway, Alexandria, Va. (July '47) *M*

Foster Eng. Co., H. Rodewald, Vice-Pres., 835 Lehigh Ave., Union, N.J. (Assoc. M. Oct. '51)

Gates, Albert J., Chief Engr., Southwestern Norcam, Box 671, Ruidoso, N.M. (Apr. '52)

Gilman, Richard H., III, 229 Gull St., Manhattan Beach, Calif. (Jan. '51)

Gordier, Robert L., 5537—26th Ave., S., Minneapolis 17, Minn. (Jr. M. Apr. '51)

Gray, Arthur E., R.D. 1, Allison Park, Pa. (Apr. '47)

Grimes, Paschal; *see* Chanute (Kan.)

Gulden, Horace B., Borough Mgr., Municipal Bldg., King & Penn Sts., Pottstown, Pa. (Jan. '40) *MRPD*

Hall, George Albro, Engr.-Secy., Water Pollution Control Board, State Dept. of Health, Columbus 15, Ohio (July '38)

Henderson, Stuart P., 102 W. Coronado Rd., Phoenix, Ariz. (July '48) *P*

Hill, Frederick G., c/o Government of Kuwait, Kuwait, Arabia (July '51)

Holland, David C., Resident Salesman, General Chemical Div., Allied Chemical & Dye Corp., 1120 Mortgage Guarantee Bldg., Atlanta 3, Ga. (Jan. '51) *P*

Holloway, J. H., Field Engr., Fairbanks, Morse & Co., 1823 Larsen St., Salina, Kan. (Apr. '51)

Hudrlik, Otto L., Northwestern Service Mgr., The Flox Co., Inc., 5329 N.E. Union Ave., Portland 11, Ore. (Jan. '44) *P*

Hughes, W. P., Cons. Engr., 220—7th Ave., Lewiston, Idaho (Sept. '25) *Director '35–'38. Fuller Award '41. MRPD*

(*Continued on page 40*)



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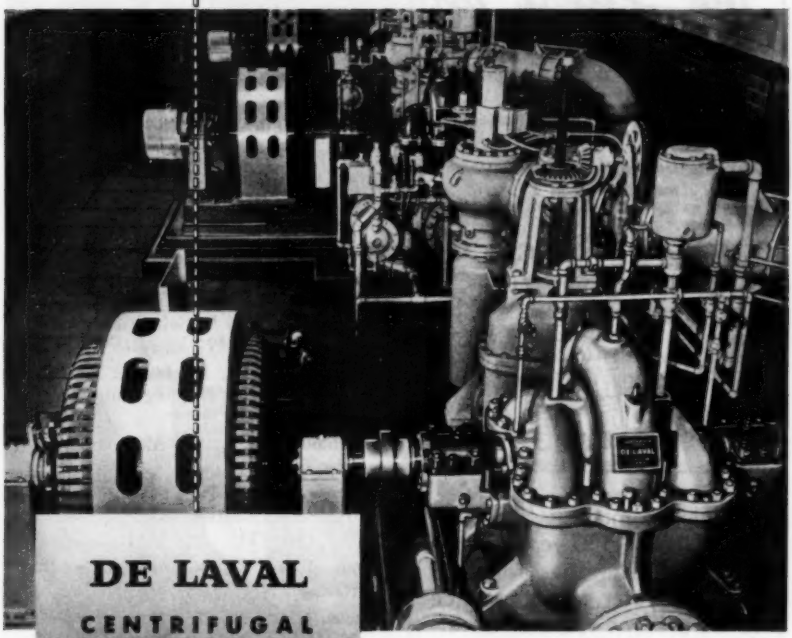
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Iola City Water Works, Paul J. Bush, Supt. of Utilities, Iola, Kan. (Corp. M. Jan. '48)

Jackson, Ray A., Apt. 21, 4316 Old Brook Rd., Richmond, Va. (Apr. '52) *M*

Jordan, Philip J., Civ. Engr., Constr. Div., 650 E. Ohio St., Chicago 11, Ill. (Jan. '51) *PD*

King, Alan G., Mathieson Chemical Corp., Rm. 1040, National Bank of Commerce Bldg., New Orleans, La. (Jan. '52)

Klaus, Fred J., 5726 Clover Dr., Oakland 37, Calif. (Oct. '15) *M*

Levy, Harold C., Administrative Asst. to City Mgr., 124 Hullett St., Long Beach 5, Calif. (Apr. '49)

Lewis, Willis H., Polglaze & Basenberg, 812 S. 27th St., Birmingham, Ala. (Jan. '43) *P*

Lindbloom, P. S.; *see* Alderwood Water Dist. (Wash.)

Lindsey, Ray W., Dist. Repr., BIF Industries, 207 Congress Bldg., Kansas City, Mo. (Jan. '51) *P*

Long, Wilbur E., Jr., 1615 Bickett Blvd., Raleigh, N.C. (July '49) *MRPD*

Lucas, Glenn T., 2150 Palos Verdes Dr., N., Rolling Hills, Calif. (Oct. '43)

Lynch, Leonard, Civ. Engr., Constr. Div., 650 E. Ohio St., Chicago 11, Ill. (Apr. '46) *P*

Massey, Carlton C., Fairfax County Mgr., Fairfax Court House, Va. (Jan. '39)

McGrann, John H., Box 51, Station C, Lincoln, Neb. (Jan. '41)

Mechanik, Joseph, 216 E. 17th St., New York 3, N.Y. (Jan. '48)

Merryman, Harold W., Asst. San. Engr., State Board of Health, 829 S. 11th St., Corvallis, Ore. (Apr. '36) *R*

Miller, Robert S., Asst. Dist. Engr., Div. of Health, 606 Sexton Rd., Columbia, Mo. (Apr. '51) *MPD*

Nesbitt, John B., Whitman, Requardt & Assoc., 1304 St. Paul St., Baltimore 2, Md. (Jr. M. Jan. '49)

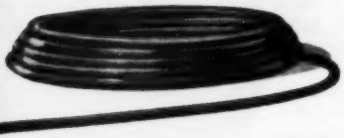
Newell, John F., San. Engr., 720—46th St., Los Alamos, N.M. (Jan. '49)

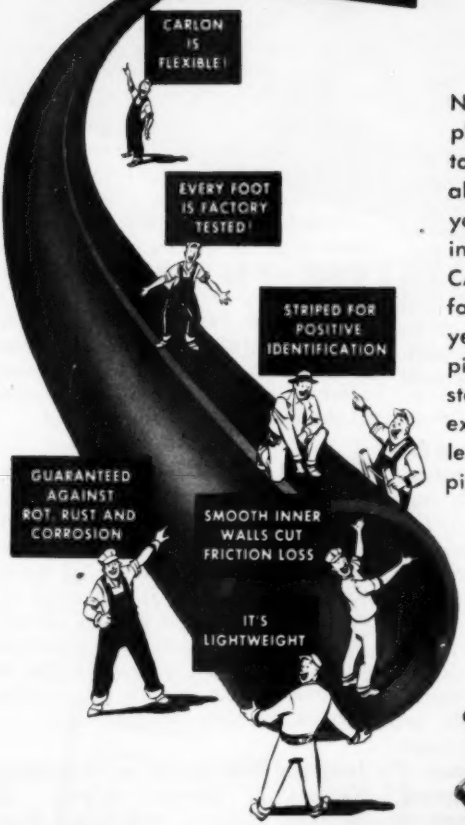
Rodewald, H.; *see* Foster Eng. Co.

Townes, C. C.; *see* Colonial Heights (Va.)

Wheeler, Charles B.; *see* Baltimore County Metropolitan Dist. (Md.)

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Condensation indicates volume 39, page 473, issue dated May 1947. **Key:** In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

SOFTENING AND IRON REMOVAL

Mexico's First Water-Softening Plant. W. E. BELL. Eng. News-Rec., **145**:18:45 ('50). The new water-softening plant at El Mante, Mexico, is described. Raw water is obtained from the River Mante and the total hardness (average 700 ppm) varies considerably. Water for domestic and industrial use is coagulated with lime, soda ash, and alum, flocculated mechanically, and allowed to settle. It is then recarbonated and finally applied to rapid sand filters. The average reduction in total hardness is 300–350 ppm, with a maximum of 560 ppm.—*WPA*

The Pista Iron-Removal Process for Water and Waste-Water Purification. H. L. BENDEL. Gesundh.-Ing. (Ger.), **72**:231 ('51). $Fe(OH)_3$ (I) from metallic Fe (II) is produced *in situ* by means of a Pista iron remover, usually being replaced by chem. pptn. Drinking H_2O can be readily prepd. from surface water and city and industrial H_2O can be purified economically. With the Pista B procedure partial biol. purification can be greatly increased by short diversion time through an airing vessel. The consumption of II is small and its H_2O soly. depends on the carbonate and pH content of the H_2O in question. Low carbonate and pH reduce II soly. owing to the formation of I.—*CA*

Aluminum Sulfate as an Aid in the Hot Lime-Soda Water-Softening Process. A. MOSIC & E. JEDERMAN. Bul. Soc. Chim. Belgrade, **16**:119 ('51). The use of 10 mg/l $Al_2(SO_4)_3$ in the hot (70 C) lime-soda process resulted in lowering of the residual hardness from 0.8 to 0.4 German degrees (excess alky.: 2 meq/l) in lab. expts., and from < 1 German degree (excess alky.: 3 meq/l) to 0.51 and 0.64 German degrees (excess alky.: 2.24 and 2.36 meq/l, resp.) in a large-scale expt., in quicker settling of the sludge, in notable clearness of the softened water, in a drop of the SiO_2 content from 9.0 to 5.0 mg/l, and in an increase of sulfate content from 25.4 to 31.6 mg SO_3/l, not sufficient, however, to cause deposition of gypsum at the existing excess alky.—*CA*

Removal of Iron from Ground Water by Adsorption. S. S. VAN DER WAL. Water (Neth.), **36** (Jan. 31, '52). It is difficult to remove Fe and Mn without floc formation and use of filter material only. If removal is insufficient approx. 0.5 ppm of Cu can be added. The activating action of the Cu is twofold: Cu acts catalytically by the oxidation of Fe; Cu aids adsorption on the filter material.—*CA*

Iron and Manganese as Disturbing Factors in Ground Water. H. MOHLER. Schweiz. Ver. Gas-u. Wasserfach Monats-Bul. (Swiss), **31**:293 ('51). Fe in concns. of 0.25 mg/l or Mg 0.15 mg/l causes difficulties in water-supply systems because of turbidity and taste. Generally the cause is lack of O and absence of aggressive

(*Continued on page 44*)

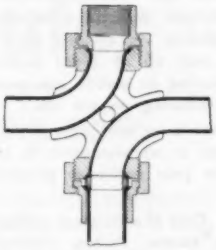


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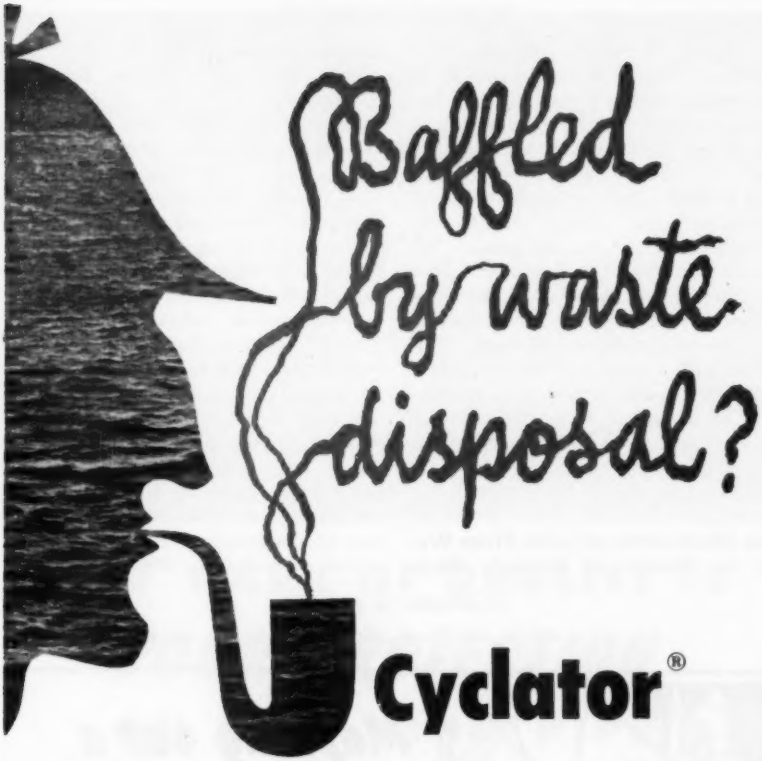
(*Continued from page 42*)

CO_2. Means for correction are discussed, such as aeration usually with chlorination to prevent *Zoögloea* growth. If the origin of the metals is the soil rather than the pipes, the problem is difficult to solve economically. Changes in ground water levels because of the construction of dams is sometimes the cause.—*CA*

Sterilization of Ion-Exchange Bodies. HENRY C. MARKS. U.S. Patent 2,571,271 (Oct. 16, '51). Beds of org. ion exchangers, used in water-softening processes in pharmaceutical and soft-drink plants, and in the manuf. of sugar, can be sterilized by treatment with chlorinated melamine (I). A soln. of I is passed through the bed at the time of regeneration, at the rate of 10 gal/cu ft of resin, for at least 20 min. I (contg. 20–100 ppm available Cl) mixed with water may be first combined with anhyd. $Na_2H_2P_2O_7$ to form a dry hydrate, easily wet for use. Wetting agents, such as Naccanol-NR, may be used for this purpose, and further increase the efficiency of the sterilization.—*CA*

Application of Ion-Exchange. Copper-Amberlite IR-120 in Fixed Beds. W. A. SELKE & H. BLISS. Chem. Eng. Progress, **46**:509 ('50). Expts. have been made to determine the mechanism of the process and the fundamental constants governing the exchange reaction between copper salts and the resinous cation-exchange material Amberlite IR-120 in fixed beds. From a knowledge of these factors it should be possible to design a suitable ion-exchange unit for any given purpose. Copper was chosen for study as it is frequently present in industrial wastes, is similar in behavior to other ions frequently found, and is easy to determine analytically. Results are interpreted mathematically. Two types of equilibrium were found. For copper-

(*Continued on page 46*)



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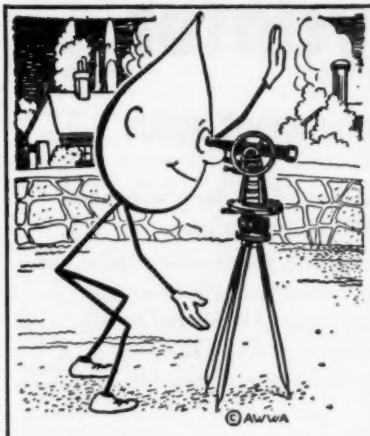
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(Continued from page 44)

hydrogen exchange the relationship is nonlinear which is characteristic of divalent-monovalent exchange. For copper-magnesium the relationship is practically linear which is characteristic of most divalent-divalent systems and probably most monovalent-monovalent systems. Copper-calcium exchange does not follow closely the theory of liquid diffusion with linear equilibrium. It is possible that solid diffusion contributes to this effect as well as nonlinear equilibrium. For resins with a wide distribution of particle size, upflow operation is preferable to downflow from the point of view of utilization of capacity of the ion-exchange material in cyclic operation.—*WPA*

The Elimination of Silica From Water by Means of Strongly Basic Anion-Exchange Resins. M. STASSART. Bul. Centre Belge Étude et Document. Eaux (Liége), 6:371 ('49). The removal of SiO_2 to a limit below 0.3 mg/l is important in the treatment of feed waters for high-pressure boilers. Some conventional methods do not permit sufficiently low SiO_2 levels to be reached—for example, the treatment with MgO (hot process), adsorption by $Fe(OH)_3$ or $Al(OH)_3$, or entrainment in $CaCO_3$ by pptn. with CaO. Strongly basic ion-exchange resins have made the direct elimination of ionized SiO_2 possible. The mechanism of this resin exchange is discussed. Owing to the fact that strongly basic resins eliminate both strong and weak acids, resulting in the formation of anionic layers in the resins which are proportionate to the strength and concn. of the acids, the demineraliza-

(Continued on page 48)



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(Continued from page 46)

tion usually has to be carried out in several stages. Exptl. data are presented showing the effect of various factors on the efficiency of the SiO_2 concn. and contact time as a function of particle diam., flow rate, and thickness of the resin bed. *Ibid.*, **7**:393 ('50). An appraisal is made of the cost of SiO_2 removal from water on the basis of data showing optimum regenerating conditions as a function of contact time and of regenerant quantity.—*CA*

Dow's Hot-Lime-Zeolite System After 18 Months. W. S. BUTLER. Power Eng., **56**:1:80 ('52). The quality of water, before and after treatment, operating details, and costs are tabulated. Lime and sodium aluminate are fed to the primary softener. A pH of approx. 10 is maintained. Details of filter handling are included. —*CA*

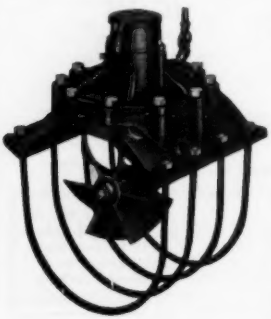
Processes for Removal of Iron From Water for Drinking and for Other Purposes. GEORG HEINECKE. Bau u. Betrieb (Ger.), **4**:2:1 ('52). Open and closed filters for removal of Fe are described and illustrated. These are filled with coke, quartz, sand, etc. Two-stage closed filters are used when filtration is difficult; the first filter uses comparatively coarse material, and the second, sand.—*CA*

DISINFECTION

The Use of Potassium Permanganate in the Disinfection of Water. R. BANERJEA. Indian Med. Gaz., **85**:214 ('50). In the disinfection of water with potassium permanganate it is necessary to use a concentration of 1 part per 50,000 and to allow a period of contact of 24 hr to ensure satisfactory results. Disinfection is not significantly affected by the pH value of the water but is retarded by the presence of more than 1 ppm organic matter. In concs. of 200,000 organisms per ml, a concentration of 10 ppm permanganate kills *Vibrio cholerae* in 2 hr, *Shigella flexneri* in 4 hr, and *Salmonella typhi* in 24 hr. With higher concentrations of typhoid bacteria, 20 ppm permanganate may not be sufficient to disinfect the water in 24 hr.—*WPA*

Bactericidal Action of Hydrogen Peroxide in Water. JAN JUST. Roczniki Panstwowego Zakladu Hig. (Polish), **1**:44 ('50). The purpose of this work was to det. the adaptability of H_2O_2 as a disinfectant for H_2O. A review of the production and bactericidal action of H_2O_2 precedes the paper. A 3% soln. in distd. H_2O loses 10% activity in 2 weeks when kept in the dark. Impurities, light, and especially sunlight speed up decompn.

(Continued on page 50)



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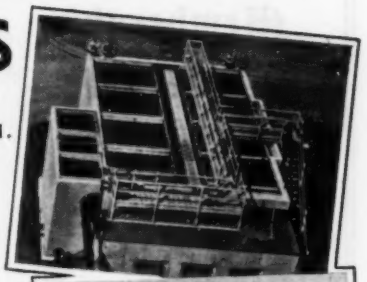
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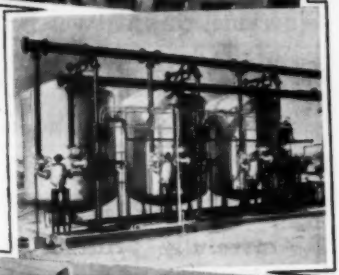
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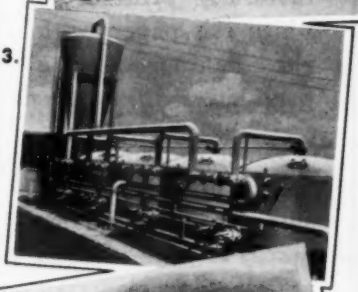
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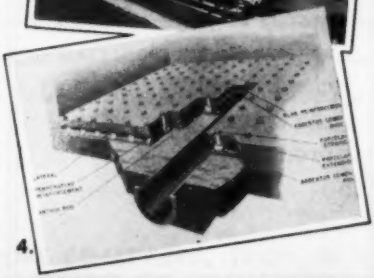
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(Continued from page 48)

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Quaternaries in Hard Water. The Influence of Hard Water on In Vivo Challenge of Disinfectant Activity of Benzylalkonium Chloride. E. W. DENNIS. Soap Sanit. Chemicals, **27**: 3:117 ('51). Concurrent *in vitro* and *in vivo* procedures were used to demonstrate the germicidal activity of benzylalkonium chloride—alkyldimethylbenzylammonium chloride (I). The highly virulent grampos. hemolytic *Streptococcus pyogenes* C-203 M (II) and the gram-neg. *Pasteurella bovisep-tica* (III) are suitable representative test organisms for *in vivo* challenge of germicidal activity. *S. typhosa* (IV) can be used as a test organism but the problems created by its low pathogenicity for mice make it unsuitable for routine use. I in a concn. of 200 ppm is an efficient anti-infective agent against several million lethal doses of II or III and against approx. 18,000 mouse infective doses of IV. The anti-infective properties of I were not reduced below a required concn. of 200 ppm even when a hard H_2O like that of Norwood, Ohio, was used as a vehicle. The period of exposure was approx. 2 min and a blood-broth inoculum of streptococci or III provided 0.5–1.0% whole blood as extraneous org. matter. Thus an *in vivo* assay with virulent II offers a realistic method of evaluating quaternary ammonium germicides to be used for sanitizing eating and drinking utensils. —*CA*

(Continued on page 52)



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(*Continued from page 50*)

Symposium on the Sterilization of Water. (A) The Installation and Operation of Gas Chlorine Dosing Plants. J. G. SMITH. J. Inst. Wtr. Engrs. (Br.), **4**:481 ('50). Difficulties associated with the measurement and application of chlorine gas for the disinfection of water are described and recommendations are made for overcoming them.—*WPA*

Bactericidal Action of Copper and Zinc in Open Water Reservoirs. A. A. GORTT-DE-GROTT. Gigiena i Sanit. (U.S.S.R.), **7**:20 ('51). Tests on typhoid organisms in water from Verkh-Iset reservoir with Cu or Zn showed that Cu is 10 times more effective than Zn; in presence of both, the activity is the sum of the individual activities.—*CA*

Some Practical Considerations on Water Sterilization by Chlorine Gas. M. J. HALLOPEAU. Tech. Sanit. et Munic. (Fr.), **45**:122 (May '50). Disinfection of potable water supplies by Cl_2 gas, introduced in France in 1933, developed rapidly in the big urban centers (Choisy-Le-Roi, 1933–35, Paris-Ivry 1936). Cl_2 appears desirable in all but the very smallest water plants. Not all operators are convinced because of poor plant design, Cl_2 disinfection needs, complication of Cl_2 dosing apparatus, direct Cl_2 injection devices, corrosion, absence of rugged chlorine water gravity feeders, and necessity of mixing with the water to treat in a pump sump. Tubings should be rubber or plastic and the design simple enough to permit efficient use by nonspecialized personnel.

(*Continued on page 54*)

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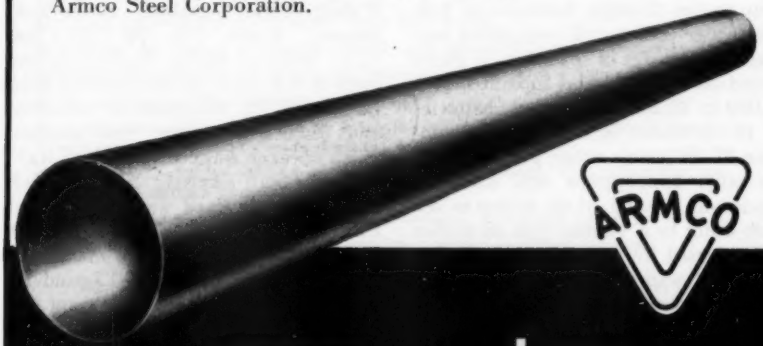
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MEETS A. W. W. A. SPECIFICATIONS

(*Continued from page 52*)

Chlorination apparatus and Cl_2 cylinders must be segregated in small ventilated chamber, with a door to the outside that would permit good ventilation and avoid corrosion of plant apparatus. There should be no long Cl_2 feedlines. Using precautions, author predicts a generalized use of Cl_2 gas in France; chloramines are not believed to be more valuable than Cl_2 for water disinfection.—*M. Albanese*

Ozone Sterilization of the Water Supply of Nice and Coastal Communities. H. BERNIER. Tech. Sanit. et Munic. (Fr.), **45**:117 (May, '50). The city of Nice and the coastal region between the Var River (west) and the Principality of Monaco (east) are supplied with water from springs (3,170 gpm) and the river Vésubie (63,500 gpm) carried by 2 canals, closed (5.5 miles) and open (18.6 mi.), resp., from northern mountains. Ozonation of these supplies is effected by 3 plants for Nice Twp. (18.2 mgd) and one for the coast communities (7.52 mgd) after filtration of the river water. The four existing plants are provided with Otto ozonators, using air dried with $CaCl_2$ or silica gel which then passes through batteries of hollow, water-cooled cast-iron plates separated by couples of spaced glass plates tinned on one side, and submitted to a 15,000 to 18,000 volt current; batteries of 10 electrodes in a glass cage produce 35–40 grains ozone per kwhr under avg. temperature and humidity conditions. Ozonized air is then mixed with water by a Venturi type emulsifier and released by aceramic diffuser under 16′5″ water in a self-contact column (concrete, 8′3″ in diam., and 18′ high), and finally released in the atmosphere by a "desaturator." Ozone needed to sterilize 1 ppm: contact time, 5 to 20 min; power used, 2.27 kv/gal/min; loss of head, 18′. The new plant has a Van der Made-Trailigaz ozonation system, in which air is ozonized in stainless steel pipes centered in glass pipes, under a tension of 8 to 10,000 v (9 such units are enclosed in a casing serving as a second electrode, and in which cooling water or oil circulates). Air is compressed at the bottom of a sterilizer under 21′4″ of water and released after 5 to 8 min contact time, dried, and reozonized. Extra fresh air makes up lost volume. Ozone needed: 0.8 ppm for sterilization; loss of head, 4′10″. The ozonization plant derives its power from water coming from filtration plants located higher, powering turbo-alternators. All ozonators are regulated by the water flow, and each plant has a completely automatic control and alarm system. Water quality, checked for 20 consecutive years by the Superior Council of Hygiene, is, since 1930, free from control due to its very high and constant grade. Because power is home-generated, treated water only costs $16.60/mil gal.—*M. Albanese*

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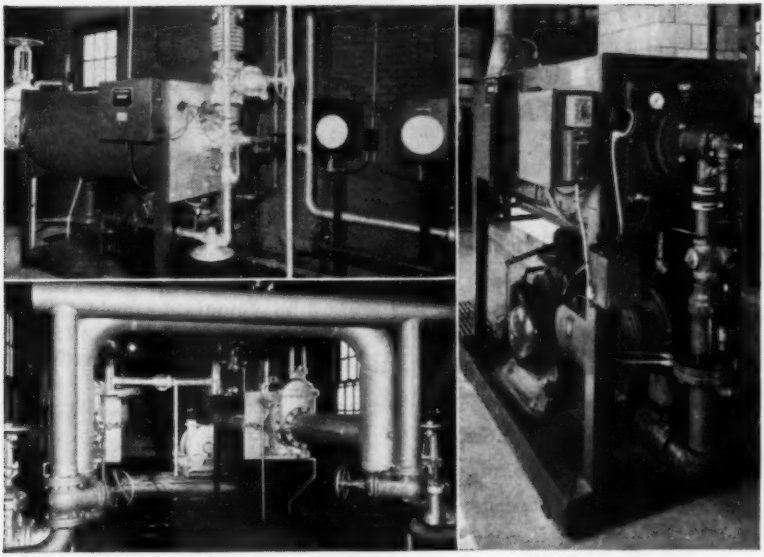
Selecting Means of Fluoridation of Public Water Supplies. H. E. ROBERTSON. Munic. Util., **90**:1:26 (Jan. '52). Relative merits, limitations, and costs of HF, NaF, hydrofluosilicic acid, CaF_2, and Na silicofluoride tabulated and discussed. Latter two compds. much cheaper sources of F than NaF, although both less sol. Soly. of NaF also limited in hard water because of CaF_2 formation. At Ca concns. of 40, 80, 120, 160, and 200 ppm, max. F in soln. at 65 F, 3.5, 2.5, 2.0, 1.7, and 1.5 ppm, resp. Na silicofluoride compares favorably with other compds. McClure demonstrated that it is as effective physiologically as NaF. Probably will become most popular source of F. Handlers of powdered F compds. should be protected from con-

(*Continued on page 56*)

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(Continued from page 54)

tact and inhalation of dust. Point of application should involve least risk of subsequent removal. Processes tending to remove F include: lime softening, alum, or Na aluminate coagulation, addn. of bentonitic clays or of activated C at low pH values. Majority of supplies in Saskatchewan contain 0.2–0.5 ppm F. Saskatchewan Dept. of Public Health has officially endorsed controlled fluoridation. Total content recommended 1.5 ppm. Higher conc. compared to that of exptl. studies elsewhere influenced by low mean annual temp. and cool summer evenings. —*R. E. Thompson*

Fluoridation Is Cooperative Matter. L. A. KAY. Munic. Util., **89**:11:26 (Nov. '51). In June '45, F, as NaF, added to Brantford supply. During previous year, 5000 children, 5–16 yr old, subjected to dental inspection, and every year since '45, 2000 of same age groups examd. In '45, avg. DMF 7.73 per child; in '50, 5.32.—*R. E. Thompson*

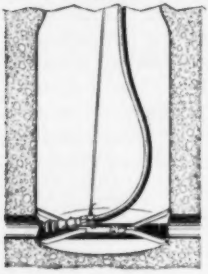
Fluorides and Dental Disease. F. A. WHITLOCK. Wtr. & Wtr. Eng. (Br.), **56**:8 (Jan. '52). Chinese Emperor Houang-Ty wrote of dental caries in 2000 B.C. In 1803 Dominico Morichini demonstrated presence of fluoride in fossilized elephant tooth found near Rome. Mottled tooth enamel was described in 1901. Churchill, in '31, demonstrated coincidence of mottled enamel and fluoride in various parts of U.S. In '37 Roholm proposed, as prophylactic measure against fluorosis, cessation of therapeutic use of fluorine compds. for children. First recorded exptl. fluoridation of water supply was made at Grand Rapids, Mich. in '45. In '50 U.S. Public Health Service stated: "Using scientific methods and procedure, communities desiring to fluoridate their communal water supplies should be strongly encouraged

(Continued on page 58)

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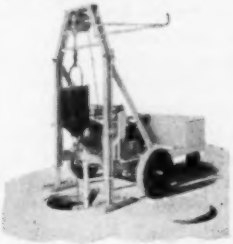


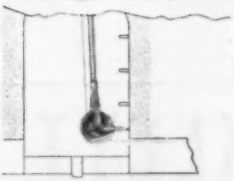
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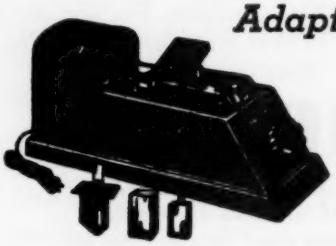
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to do so." By Feb. '51 no less than 7 organizations in U.S. had approved fluoridation. Dental caries is caused by acids resulting from action of microorganisms or carbohydrates. It is characterized by decalcification of organic portion of tooth, and is either accompanied or followed by disintegration of organic substance. Certain bacteria, notably *Lactobacillus Acidophilus*, have long been considered to be implicated in dental decay processes. It is believed that fluoride ion inhibits acid formation activity without necessarily affecting viability of causative organism. Epidemiological studies show that inverse relationship exists between concn. of fluorides and incidence of dental caries. Optimum concn. exists at approx. 1.0 ppm. Large-scale studies have been conducted in U.S. on impressive scale—for example, at Newburgh and Kingston, N.Y. For fluoride ingestion to be effective it must take place during teeth formation period, during first 8 yr of life. Effect of fluoride is detectable in adults who have been raised in areas served by water supplies containing 0.8–1.0 ppm. Investigation of possible toxic effects of fluorides is in progress. Lethal dose has been estimated as approx. 4.0 g. Acute morbidity may be caused by 0.25 g. Nothing has been shown to suggest that prevalency or malignancy of cancer is affected by exposure to waterborne fluorides. Methods of removal of fluorides include: filtering through prepared bone media contg. calcium phosphates; adsorption with aluminum compds.; ion exchange by complex metal chloride silicates, specially treated asphaltic materials, and an organic resinous anion exchange material made from diaminobenzenes or phenols and formaldehyde;

(Continued on page 60)

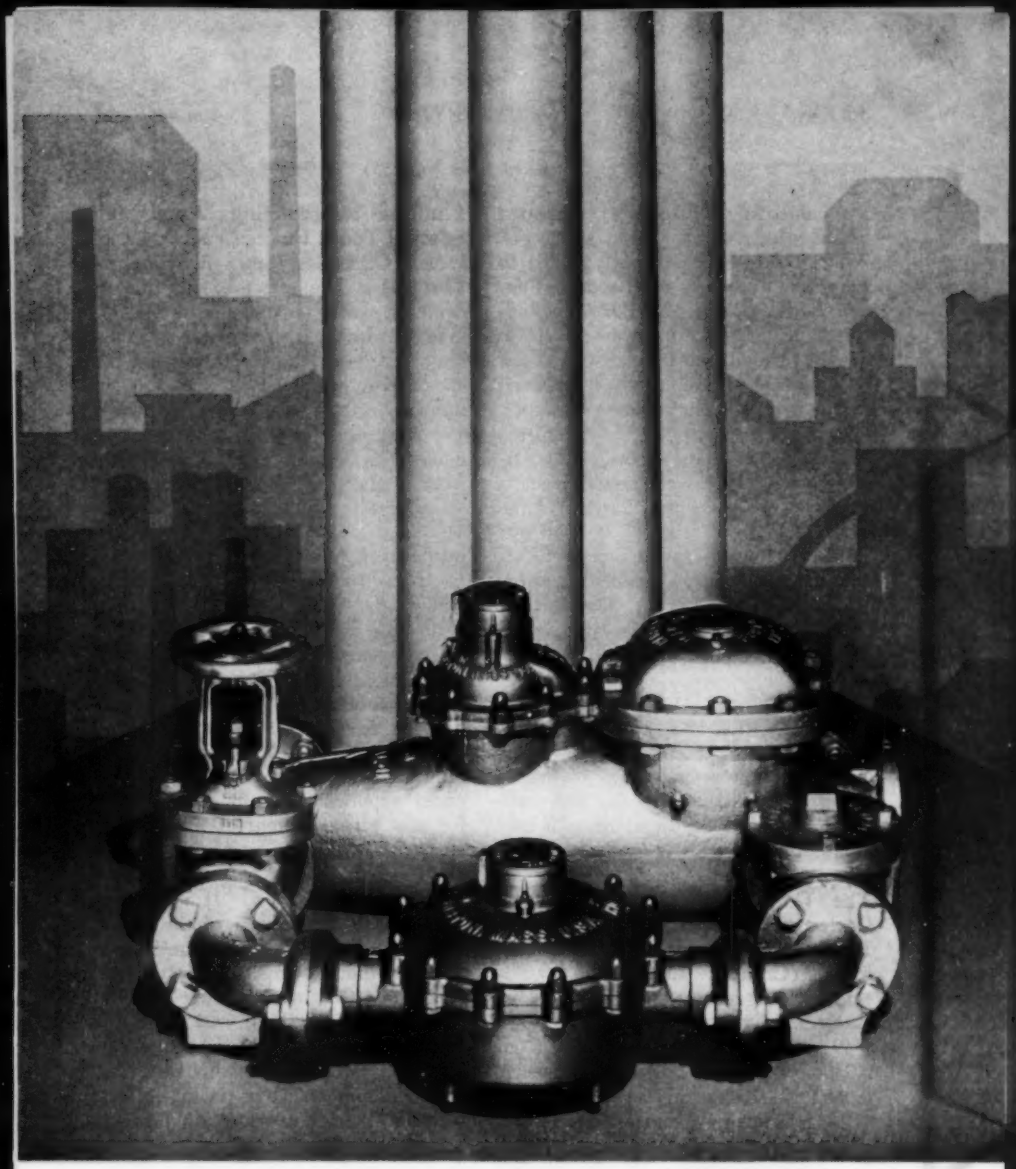
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(Continued from page 58)

lime softening; magnesia; activated carbon; fullers earth; and silica gel. Fluoride ion is conveniently added to water supplies in form of sodium fluoride, sodium fluosilicate, and as fluosilicic acid. Care must be taken in handling of all fluorides. Hazard can be elimd. by suitable precautions, such as provision of vacuum dust extractors. Point selected for addition of fluoride to water supply does not appear to be particularly critical. It would perhaps be preferable to apply it as last stage of treatment. Preferred method for detn. of chloride in drinking water is that recommended by Joint Committee of Inst. Wtr. Engrs., Royal Inst. Chem., and Soc. Pub. Analysts. The preferred method is a colorimetric procedure using zirconium alizarin reagent. Pink color is discharged in presence of fluorides, solution becoming yellowish. Interesting side effect of fluoridation is brittleness of manufactured ice. Difficulty was overcome at Charlotte, N.C., by addition of ammonium chloride.—*H. E. Babbitt*

The Correlation Between Dental Caries and the Fluorine Content of Drinking Water in Hrvatsko Primorje (Croatian Littoral). D. Tomic, V. Rittermann, & R. Udovic-Erak. Folia Stomatol. (Yug.), **10**:85 ('49). The F content varies from 0.030 to 0.100 mg F/l, the avg. being 0.060. The dental caries rate for adults (21–35 yr) is 84% in Senj and 100% in Rijeka, the avg.% of carious teeth in one person being 27 (in Rijeka: 34.9). At the Rijeka Children's Hospital the dental caries rate is 95%, the avg.% of carious teeth in one child (avg. age: 9.7 yr) being 22.2. At the Children's Home in Lipik (northern Croatia), where the water contains 0.290–0.482 mg F/l, the dental caries rate is only 78% and the avg.% of carious teeth in one child (avg. age: 11.3 yr) is only 7.0%.—*CA*

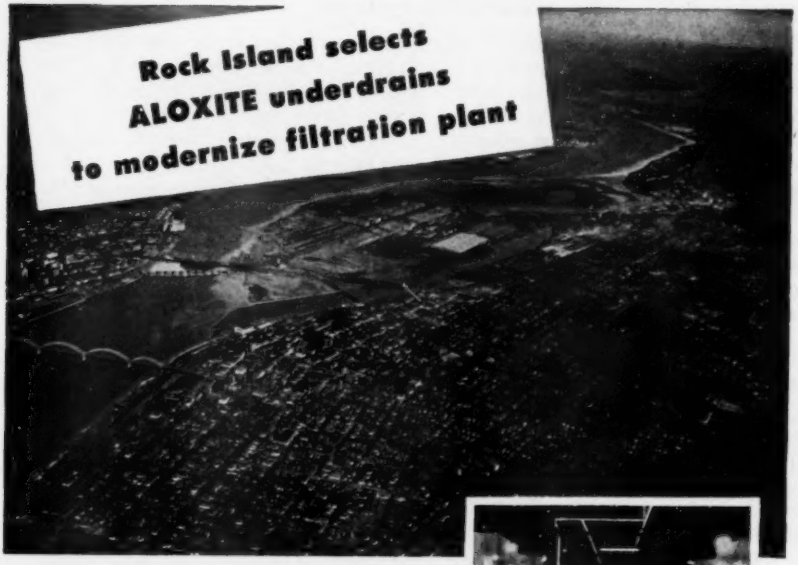
Fluorine in Drinking Water and Spotted Tooth Enamel. R. D. Gabovich. Gigiena i Sanit. (USSR), **8**: 13 ('50). The effect of fluorine in drinking water on tooth enamel is reviewed. In the Ukraine it was found that there was a rapid increase in the spotting of enamel when the conc. of fluorine in the water supply rose from 1 to 4 mg per l, and that with concs. of more than 4.2 mg per l more than 33% of the population showed severe spotting of enamel.—*WPA*

Something New in Fluoridation. J. H. Svore & A. E. Williamson. Off. Bul. N. D. Wtr. & Sew. Wks. Conf., **18**:8,9:2 ('51). Data from 24 surveys on the incidence of dental caries among school children in various communities have been analysed to det. the relation between age of child and DMF (decayed, missing, filled) value as a function of the content of fluorine in the water supplies. Results indicate that for any given content of fluorine the curve showing the relation between DMF rate and age was typical of a unimolecular reaction. It is considered that a comparison of the values of the reaction constant would be a better method of detg. the effectiveness of adding fluorine to water supplies than comparing DMF rate per child with a fixed std., such as age. Interpretation of the data in this way indicates the importance of having at least 0.1 ppm fluoride in water supplies and preferably more than 0.35 ppm.—*WPA*

Fluorine in Drinking Water. M. De Ridder. Bul. Centre Belge et Doc. Eaux (Belg.), **7**:421 ('50). The effects on man of fluorine in drinking waters are discussed with reference to water supplies in the U.S. and South Africa.—*WPA*

Research Into Fluoridation Effects. M. Dantow. Munic. Util., **89**:11:26

(Continued on page 62)



Information courtesy Rock Island Dept. of Public Works



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(*Continued from page 60*)

(Nov. '51). Events which led to establishment of relationship between F and mottled tooth enamel and incidence of caries reviewed. As of Feb. 1, '51, 68 cities known to have adopted fluoridation. Reduction in caries incidence reported in all communities in which study projects undertaken. Summary of results included: reduction varies from approx. 20% in older age groups to approx. 50% in youngest group. F compds. toxic, but so are Cl and I, in excessive amts. Also, F present in various concns. in foods. Estd. daily F intake from food 0.19–0.32 mg. In temperate climates, avg. adult drinks 1200–1600 ml water daily; if F concn. 1 ppm, 1.2–1.6 mg ingested from this source. Balance soon established in body between F storage and excretion: 70–90% excreted in urine. No damage to bone structure and kidneys found when water contains up to 5 ppm F; at 1 ppm, no toxic effect except slight marring of enamel in small percentage of cases, unrecognizable by layman in many instances. Most dental and health authorities believe that it is no longer necessary to wait until present studies completed before adopting fluoridation. Saskatoon water contains 0.1 ppm F. Local committee appointed to study fluoridation recommended adoption.—*R. E. Thompson*

Public Health Aspects of Water Fluoridation. HERMAN E. HILLEBOE & DAVID B. AST. Am. J. Pub. Health, 41:1370 (Nov. '51). Water fluoridation represents a significant advance in public health practice. Practicability of the operation, relatively low cost as compared to proven benefits, existence

(*Continued on page 64*)

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(Continued from page 62)

of evidence that continued ingestion of excessive fluoride presents no other hazard than mottled enamel, coupled with the concept that the practice is preventive rather than curative, strongly indicate desirability of accepting fluoridation of water supplies as a sound attack on the dental health problem.—*PHEA*

Ontario Municipality Begins Water Fluoridation. Eng. & Contract Record, **65**:5:102 (May '52). Fluoridation with NaF inaugurated at Fort Erie, Jan. 18, '52. F content of supply from Niagara R. increased from 0 to 1.0–1.2 ppm. Equip. includes dry feeder and soln. mixing chamber.—*R. E. Thompson*

Water Supply of the City of São Paulo, and its Fluorine Content. M. A. P. CAMPOS. Ann. Fac. Farm. e Odont. Univ. S. Paulo (Braz.), **7**: 209 ('48–'49). The author reviews the relation between the incidence of dental caries and the content of fluorine in drinking water. The water supply of São Paulo, Brazil, contains 0.04–0.08 ppm fluorine.—*WPA*

STREAM POLLUTION CONTROL

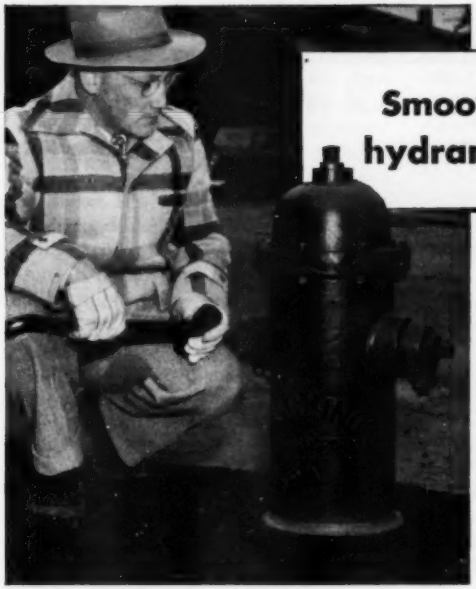
The Water-Pollution Control Program of Ohio. B. M. MCDILL. Eng. Exp. Sta. News, Columbus, O., **23**:2: 18, 38 ('51). An acct. is given of legislation concerning the control of poln. of surface waters in Ohio, with special reference to the status of the Ohio State Dept. of Health and to the organization and activities of its Water Poln. Control Unit.—*WPA*

Ohio Health and Water-Pollution Control. F. H. WARING. Eng. Exp. Sta. News, Columbus, O., **23**:2:20, 40 ('51). To enforce compliance with the Ohio R. Valley Water Sanitation Compact, legislation has been enacted prohibiting the discharge of untreated sewage and industrial waste waters into surface waters of Ohio. A survey has shown that 47 cities in Ohio have no sewage-treatment works. It is proposed to construct plants to serve Cincinnati and five suburban cities. The need is stressed for a thorough investigation to find all areas in the state where treatment of sewage and trade waste waters is inadequate. The problem of financing new works is discussed.—*WPA*

The Lake Erie Pollution Survey. C. V. YOUNGQUIST. Eng. Exp. Sta. News, Columbus, O., **23**:2:12, 34 ('51). The purpose and organization of the survey of poln. in Lake Erie being carried out by the Ohio Dept. of Natural Resources are described. Preliminary investigations have included collection of data on the quality of sediment discharged into the lake by rivers, and bact. and chem. analyses of tributary rivers. On the basis of information so far obtained, an est. is made of the extent and nature of poln. in streams entering Lake Erie and of its effect on the use of waters of the lake for industrial and other purposes. —*WPA*

$1,500,000 Expenditure by Windsor Industry to Curb Detroit R. Pollution. Munic. Util., **90**:26 (May '52). In accordance with aims of International Joint Com. on Poln. of Boundary Waters, Hiram Walker and Sons has placed in operation plant for converting stillage (fermentation residues) from 5000-bu distillery into distillers' dried grains and dried solubles, used as stock feeds. Formerly, approx. one-half recovered. Production of 1 bbl whiskey requires approx. 10 bu grain and yields 200 lb feed, which, properly fed, will produce more meat than the 560 lb original grain. Believed that

(Continued on page 66)



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(Continued from page 64)

revenue from products recovered will at least pay cost of recovery.—*R. E. Thompson*

Water Pollution Control. Preliminary Report, Assembly Interim Committee on Air and Water Pollution. Assembly of the State of California ('51).

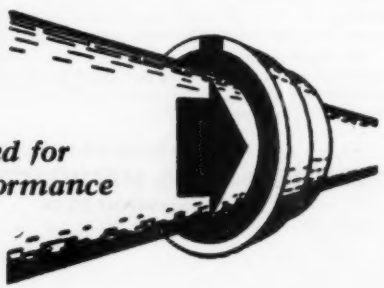
1. *Water Pollution Control Boards.* In the early months of '50, the Dickey Water Poln. Act (Ch. 1549, Statutes of 1949) was implemented by appointment of the nine regional water poln. control boards and a State Water Poln. Control Board. Offices were established at principal cities in each of the regions, and organization of the boards has proceeded rapidly under appointed executive officers. Despite the brief period during which this program has been in operation, it is obvious from the reports of the boards and reports received from many sources, that real progress is being made not only in the prevention of water poln. but also in the rapid correction of damaging and dangerous conditions which have existed for many years. The progress is reported from every region of the state of Calif.

The concurrent statute which strengthened the public health aspects of the water poln. control program and returned primary responsibility for control to the local level (Ch. 1550, Statutes of 1949) has resulted in a substantial start upon this difficult phase of the problem. The public health authorities anticipate that, in spite of budgetary and personnel problems, the next 2 yr will see this phase of the water poln. program, and particularly the regulation of public water supplies, brought under complete control.

With the exception of the extension of the powers of the regional boards in the field of water well drilling, which is discussed below, only minor amendments to these laws are indicated at this time. These include: the exception of discharges from single households under the requirement for filing of reports; a specific statement that the regional boards shall not specify the location of any particular treatment plant (in addition to the existing prohibition against specifying the design or manner of treatment); a provision for a central recording of the official actions of the various regional boards in the office of the state board; and a provision to enable the state board to assist the citizens in local areas where formation of some type of district is necessary for abatement of poln.

2. *Water Well Drilling Standards.* After thorough discussion with the regional and state Water Poln. Control Boards, representatives of the water well drilling profession, the Div. of

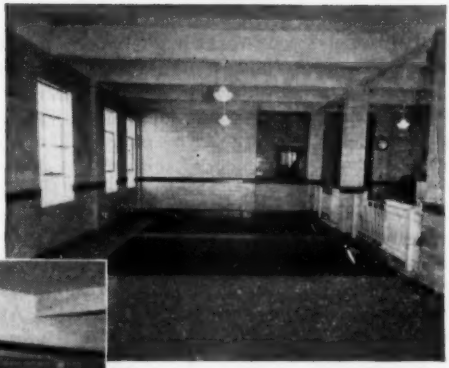
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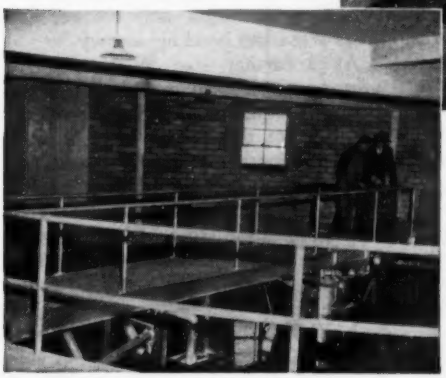
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(*Continued from page 66*)

Water Resources and others, it is concluded that further steps can be taken at this time toward obtaining adequate control of water well drilling practices in critical areas where poln. of water may occur through interconnection of pold. surface waters or waters in strata of different quality.

In the series of poln. laws enacted in 1949, Ch. 1552 directs the Div. of Water Resources (among other things) to . . . *"investigate and survey conditions of damage to quality of underground waters . . . caused by improperly constructed, abandoned, or defective wells through the interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water poln. control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water. . . ."* At that time, however, no authority was given to the regional boards to adopt the standards of well construction recommended by the division, nor were the boards given any other jurisdiction over water quality problems not involving sewage or industrial waste.

It is therefore proposed at this time that authority be granted to the regional boards to adopt the recommended standards of water well construction which may be presented by the Div. of Water Resources for defined critical areas in which water poln. is occurring or is threatened. The stds. would be applicable only in the exact area defined by the Div. of Water Resources, and authority of the regional boards would not extend to modification of the stds. proposed for such critical areas. The regional board would be directed to hold public hearings and either adopt the recommendations as presented or refer them to the division for further study. Enforcement of the provisions would rely largely upon disciplinary action against licensed contractors who might violate the provisions.

It is further proposed that the regional boards be empowered to order remedial work done whenever they find that a well has been improperly constructed. Under a new licensing procedure which is proposed, water well drillers would be required to post suitable performance bonds to insure compliance with construction stds. adopted by the regional boards. If any order of a regional board for remedial work is not complied with, the board would be authorized to contract for the work and recover the costs from the bonding agency.

As a further step in this control program, it is proposed that advance notice of intention to drill a well in any part of the state always be filed with the appropriate regional board—not in any sense as an application for a permit to construct a well, but merely as a notification, so that, if standards have been established for the particular area, the well driller may be properly advised.

3. *Water Well Drilling Contractors.* At the 1949 Session a bill to provide for separate licensing of water well drilling contractors failed to pass. In lieu of the proposed bill, certain amendments strengthening the enforcement powers of the Contractors' State License Board relating to water well drillers were enacted. During the interim period, considerable progress has been made in bringing water well drillers under license, but it is considered that some further steps should be taken at this time.

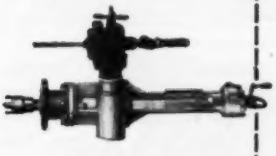
The most important consideration in the licensing of these contractors is the detn. of whether or not the applicant is honest and thoroughly skilled in his profession. Representatives of the well

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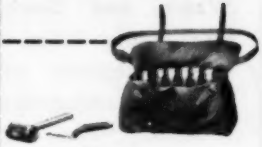
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(*Continued from page 68*)

drilling profession and many others interested in this problem feel that the present procedures of the Contractors' State License Board to accomplish this can be improved. It is therefore proposed that within the structure of the present Contractors' License Board, a separate or subboard be established for the purpose of examining applicants and taking disciplinary action. In effect, this would create a separate licensing procedure without setting up a new administrative agency.

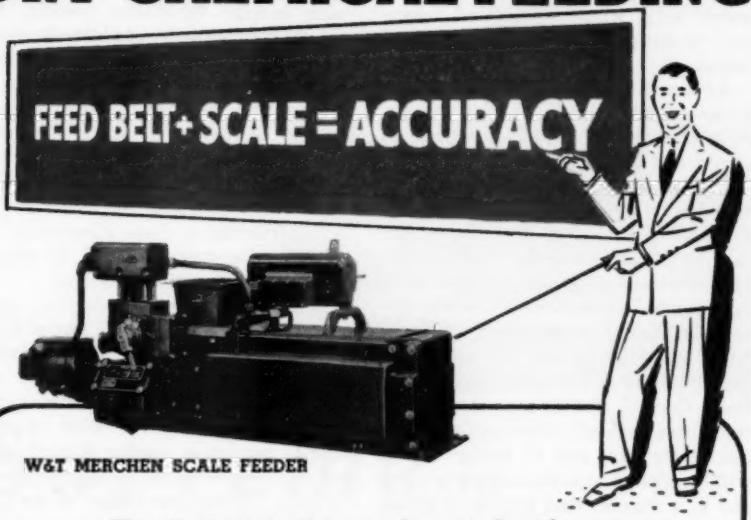
This procedure under the Contractors' State License Board, rather than an entirely separate admin. body for licensing of water well drillers, has been made possible by a superior court decision handed down in the case of *Bowline* v. *Gries* (July '50) in which it was ruled that the so-called agricultural exemption of the contractors' license law does not extend to water well drilling. Until this was done it was virtually impossible to enforce the present licensing procedure in this profession. In order to make certain that no doubt remains about the exclusion of well drilling from the agricultural exemption, it is proposed to amend that section of the contractors' license law with a specific exception of water wells.

In addition to this amendment, it has been recommended by the Registrar of Contractors that the provision which exempts contracts under $100 value be repealed as it relates to water wells. This exemption has made evasion of the present licensing procedure possible by the device of an unscrupulous operator renting his equipment to an owner, and then hiring out as an employee for wages.

4. *Abandoned Wells.* In order to implement the recommendations of the Div. of Water Resources on abandoned water wells which may be causing poln. of underground reservoirs, it is proposed that a sum of money be allocated to the State Water Poln.

(*Continued on page 72*)

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(*Continued from page 70*)

Control Board for reallocation to the Div. of Water Resources for specific work in sealing existing abandoned water wells where considered necessary to the protection of underground basins.

An amendment to the existing law which requires filing of logs of new wells is proposed to include reports of repair and abandonment of wells.

5. *State Water Poln. Control Fund.* The 1949 Legislature allocated to the State Water Poln. Control Board the sum of $1,000,000 to be available for loan to communities that are unable to finance adequate sewerage facilities under established financing procedures. After thorough study of the admin. procedures in this act, the State Water Poln. Control Board has submitted to committee several recommendations to clarify the law and to insure that it will be applied in actual hardship cases and in a manner that will be of greatest benefit to the state. The committee concurs in these recommendations and they are presented as transmitted by the board.

In addition to these changes, it is believed that provision should be made now to increase this fund by the residue of the funds appropriated by the 1947 Legislature in the Construction and Employment Act, Ch. 20, and the residue of funds appropriated for planning under Ch. 47, Fourth Extraordinary Session, 1944, when those acts expire. These funds were originally appropriated to the cities and counties with specific legislative priority for construction of poln. abatement works. This step is more than ever necessary for the protection of the public health at this time because of possible damage to sewage and waste treatment works from acts of war or other disaster, and it is further proposed that priority be provided for assistance in reconstruction of these community facilities whenever damaged by floods, acts of war, or other disaster.

6. *Salt Intrusion.* A further application of the State Poln. Control Fund is considered necessary at this time—that is, a provision to empower the state board to assist local communities in construction and operation of projects to correct or prevent the intrusion of saline waters into underground reservoirs. The recent report of the Div. of Water Resources, prepared for the State Water Poln. Board, clearly indicates the emergency nature of this problem. The physical remedies for the condition, particularly the maintenance of the so-called fresh water barrier, appear to justify one or more field projects to det. the feasibility of this procedure. Such projects, however, may be beyond the capacity of local authorities to construct and operate, and since they would be of great value

(*Continued on page 74*)

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(Continued from page 72)

to the state as a whole, it is considered that participation by the state in these costs is fully justified. It is proposed that the state board be empowered to grant such funds with adequate provision for record and study of the results of the project.

Another recommendation with respect to salt intrusion has been transmitted to the committee by the State Water Poln. Control Board. It is proposed that the board be authorized to initiate adjudication proceedings in any area where overpumping of wells is causing salt intrusion which threatens to destroy the underground basin. This action would be taken only after investigation by the Div. of Water Resources, and full public hearings within the region affected. The state would bear the costs if the Div. of Water Resources is appointed to act as referee.

In order to make this proposal practically effective, consideration should be given to amendment of the statutory procedure for adjudication of water rights to include underground as well as surface waters.

Waste Treatment at the Montierchaume Distillery. M. RENARD. Tech. Munic. et Sanit. (Fr.), **45**:226 (Oct. '51). The distillery, 5.2 miles from Chateauroux-Deols (40,000 pop.), designed for 300 tons of sugar beet per day, discharged its untreated effluent into a tributary of the Indre R. near the city's supply of spring water. These catchments were severely pold. by organic matter from distillery slops seeping through the fissured limestone during the very dry summer of '49. Treatment by spraying over deeply plowed (1′6″) ground was selected, the seepage ultimately to end in a small stream. Filtration rate, porosity, and permeability coefficients were determined, along with the depth of ground over bedrock (3′4″–3′7″) at a site approved by the state geologist, and adjudged sufficient for absorbing 3.78 gpd per acre of mixed wastes (3/5 slops) and the max. rainfall (2.62″ per mo) with a safety factor of 4 to 6. Spraying was effected with 3 removable rotary gun type sprinklers connected with the plant's waste settling basins. Actual operation (Oct. 19–Dec. 12, '50) showed effective waste disposal by complete absorption by the ground (max. time needed—6 hr.), and no appreciable modification of the pH, clearness, odor, or fishlife of the small stream. An abnormal rainfall (6.5″ in Nov. '50) produced surface runoff of dilute waste, but controlled release prevented bad effects, except a little growth of *Sphaerotilus* and green algae. Twice as much land plowed along level curves is preferable to the present area, and continuous operation would insure more regular sprinkler functioning. Pipe and equipment corrosion will be avoided by mixing lime with waste before spraying, instead of liming the soil directly. Fertilization by N, P_2O_5, and K_2O from the waste is 10 to 50 times more than normally needed for sugar beet or grain culture. —*M. Albanese*

Purification of Streams in the Grand Duchy of Luxembourg. M. GILLEN. Bul. Centre Belge et Doc. Eaux (Belg.), **5**:201 ('49). In the Grand Duchy of Luxembourg, some streams are still unpold. but others are heavily pold. The river Wiltz, which has an avg. flow of 1.5 cu meter per sec, is pold. with sewage and waste waters from two tanneries, a brewery, a dairy, and a slaughterhouse. The river Alzette, and its tributaries, the Kaylbach and the Dudelingerbach, are heavily pold. with sewage and waste waters from various industries. The results of analyses made in 1945 at different points on the river Alzette are given in a table. The temp. of many of the

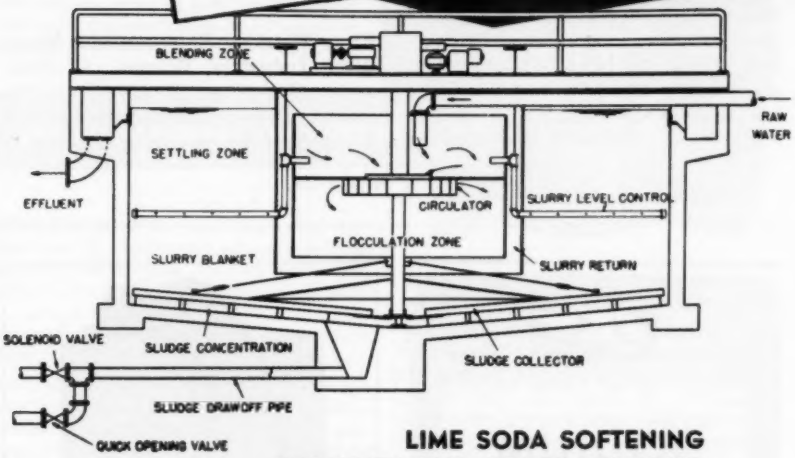
(Continued on page 76)

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(Continued from page 74)

waste waters discharged into these streams is high and sometimes the temp. of the river water may be 6.7 C higher than atmospheric temp. Small streams are often heavily pold. with sewage and garbage from villages. Legislation concerning poln. in the Duchy, including stds. for the treatment of effluents before discharge, is reviewed. Strict enforcement of regulations to control poln. and the provision of plants for treating sewage and trade waste waters before discharge are recommended.—*WPA*

Water-Supply Protection in Switzerland. Otto Jaag: Gas-u. Wasserfach (Ger.), **93**:145 ('52). In recent years heavy contamn. of Swiss lakes has caused a reduction in O content of many of the lakes other than those at the edge of the Alps. As a result, FeS tended to deposit and the red *Oscillatoria rubescens* was found in large quantities. Under these conditions, only a poor quality of fish can be recovered from the lakes. Some cantons have passed laws to regulate the flow of sewage into streams and lakes, but must suffer from contamn. higher up on the stream. National action is pending to forbid the introduction of unpurified sewage into public or private waters. Many communities have built or are building sewage-purification plants.—*CA*

Flow-Metering Equipment for Measuring Industrial Wastes. G. Newberg. Mech. Eng., **73**:588 ('51). The author discusses the characteristics of instruments for measuring the flow of

(Continued on page 78)

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(*Continued from page 76*)

liquids, particularly sewage and trade waste waters, in completely filled pipes and in partially filled pipes and open channels. The type of meter chosen depends on the conditions under which it will be operating. Special consideration must be given to corrosive liquids and liquids containing suspended solids.—*WPA*

Aquatic Invertebrates as Indicators of Stream Pollution. ARDEN R. GAUFIN & CLARENCE M. TARZWELL. Public Health Rpts., **67**:57 (Jan. '52). This paper is the first in a series of biological studies of stream sanitation. It deals with diurnal variations in temp. and oxygen in a stream pold. with oxygen-depleting wastes. It was found that diurnal variations are greatest in the spring and summer period and are slight during winter. Areas which are in the lower part of the septic zone have the highest oxygen concns. in the afternoon but oxygen may almost disappear during the night. As the summer advances, oxygen depletion becomes progressively more extensive and by late summer the septic zone is established where oxygen is absent or nearly absent during the 24-hr period. Physical-chemical conditions were correlated with aquatic oppulations so that given sets of physical-chemical conditions were directly related to the fauna which developed. In investigating the use of biological indicators, the following conclusions were reached: 1. Single species of organisms such as *Tubifex tubifex*, or *Chironomus tentans* cannot be used safely as indicators of poln. unless their relative abundance is considered; 2. The absence or much reduced numbers of formerly present clean-water species constitutes an important index in evaluating the degree of poln; 3. The quant. and qual. composition of an aquatic pop. constitutes a valuable index in delineating zones of poln. in a stream; 4. In interpreting the distribution of organisms in a stream as an index of pollutional conditions, all environmental factors should be considered; 5. Pollutional associations are characterized by few species but large numbers of individuals; 6. The association of organisms normally present under most septic conditions is characterized by the absence of plant and animal eaters and the presence of scavengers; 7. Organisms characteristic of septic zones are those which can exist under conditions of very low oxygen or have adaptations for breathing atmospheric oxygen; 8. Nocturnal deficiencies in dissolved oxygen is often the critical environmental factor which det. the distr. of organisms in a stream; 9. Under conditions of organic poln. diurnal-nocturnal deficiencies in oxygen are sometimes concomitant with supersaturation of dissolved oxygen.—*PHEA*

Example of Controlling Sewage Pollution of a Small River. F. HOLINGER. Trav. Congr. Int. Limnol. (Swiss), **10**:173 ('48–'49). Although there are no large towns in the Canton Baselland, Switzerland, some streams are considerably pold. because of their low natural flow—for example, the vol. of sewage discharged from Liestal (pop. 8000) is more than half the avg. flow in the river Ergolz; during the exceptionally dry period in '47 the Ergolz consisted almost entirely of sewage. The author describes investigations made to determine the most economical method for reducing poln. of the Ergolz. There are 8 communities in the valley and 55 industrial establishments of various kinds. It was concluded that the cheapest method would be to construct a single primary treatment plant and to discharge the effluent to the Rhine; this, however, would greatly reduce the flow in the river Ergolz. The scheme recom-

(*Continued on page 80*)

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(*Continued from page 78*)

mended was the construction of three treatment plants to serve 4, 1, and 3 communities, respectively, and the discharge of the treated effluents to the Ergolz.—*WPA*

Vitamin Content of Produce and Products Used on Farms. II. Vitamin B_1 in Fodders From Meadows Irrigated With Sewage Water and With Clean Water. C. ANTONIANI & A. MONZINI. Ann. Sper. Agrar. (Ital.), **4**:625 ('50). The content of vitamin B_1 was found to be higher in fodder from meadows irrigated with sewage effluents than in fodder from meadows irrigated with water. The content of vitamin B_1 in sewage effluents in Milan is given.—*WPA*

HEALTH AND HYGIENE

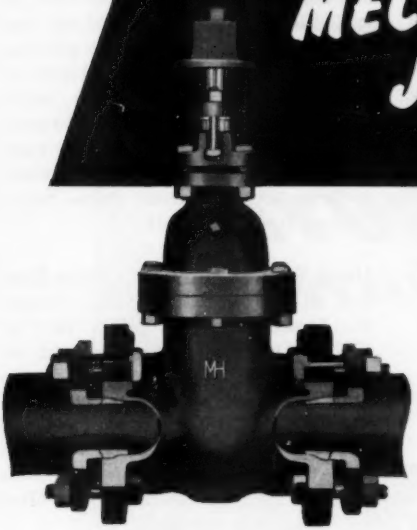
Innocuousness of the Addition of 1 ppm of DDT to Drinking Water for the Eradication of Aedes aegypti. HECTOR ABAD GOMEZ. Bol. Oficina Sanit. Panamer., **30**:330 ('51). Addn. of 1 ppm of DDT to public water supplies once a month or twice a year is considered to be harmless to people consuming the water, on the basis of a literature survey of the toxicity of DDT to warm-blooded animals.—*CA*

Epidemiology of Typhoid-Paratyphoid Infections in Marseilles, 1940–1950. R. BESTIEV. Tech. Sanit. et Munic. (Fr.), **47**:15 (Jan. '52). A typhoid-paratyphoid morbidity index of 594.2 (per 100,000 pop.) and a mortality index of 112.08 during the 1940–1950 decade in Marseilles show an endemic trend of these diseases; however, use of antibiotics has reduced the mortality index 30 to 90% in the last 3 yr. Principal factors of endemicity include: the city's supply of drinking water (49.5% of cases), shellfish (26.3%), and well water, ice cream, cooling ice, contaminated vegetables, and inter-human contamination account for the remainder (24.06%). The drinking water factor has been steadily reducing in importance in the 10-yr period decreasing roughly from 70 to 24%, but not enough to suppress endemicity. The shellfish factor, in spite of some small decrease in the first five years, increased from 36 to 40 (morbidity index/100,000 pop.) during 1945–50. Shellfish harvesting (mussels, mostly) still proceeds in the neighborhood of the harbor and near estuaries of the area, and products are frequently marketed without rinsing or sterilization. Measures taken to reduce pollution include suppression of shellfish beds within the harbor, complete epidemiological investigation of each reported case of typhoid, generalized (but not compulsory) anti-typhoid-paratyphoid vacci-

(*Continued on page 82*)



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(*Continued from page 80*)

nation, water sampling at domicile of cases, systematic control of food industries using water and compulsory private sterilization of water by such manufacturers, bacterial control of swimming pools and beaches, more severe surveillance of shellfish dealers, wholesale and retail. Results of these policies are encouraging, but not fully satisfactory because of lack of legally recognized *Esch. coli* standards for shellfish growing waters, compulsory rinsing or sterilization of shellfish before sale, and lack of adequate penalties in the existing laws for delinquents.—*M. Albanese*

TASTE AND ODOR CONTROL

Point of Application for Activated Carbon. O. J. Smith. Taste & Odor Control J., **17**:3:7 ('51). The author discusses factors affecting the choice of stage in treatment at which activated carbon should be applied to water to control tastes and odors and as an aid to coagulation.

Chicago Controls the Taste With Carbon Slurries. John R. Baylis. Am. City, **66**:12:108 ('51). The application of activated C in the form of a slurry produced by mixing powdered C in tanks fitted with paddle mixers and at dosage rates up to 70 lb activated C/mil gal H_2O removed tastes from H_2O received from a lake supply. —*CA*

The Effect of Chlorine Dioxide on Taste and Odor Removal. L. C. Domke. Taste & Odor Control J., **17**:3:5 ('51). An account is given of the use of chlorine dioxide in treatment of water for the control of tastes and odors. At Waukegan water works, application of 2 to 4 lb of chlorine dioxide per mil gal of water was no more effective in controlling tastes and odors than less costly methods of control. Water treated by chlorine dioxide had a sweetish, aromatic taste, noticeable but not unpleasant. Recent work has shown that chlorine dioxide will eliminate all chlorophenol odors in water probably as a result of the oxidation of orthochlorophenol to odorless trichlorophenol. Chlorine dioxide is also effective in controlling odors caused by organic matter from swamps and by some types of algae, and is more effective than chlorine in the control of bacteria and bacterial spores, but it reacts more slowly.—*WPA*

Using Sodium Nitrate for Odor Control in a Polluted Stream. Philip N. Albright. Pub. Wks., **82**:8:57 ('51). Odors arising in a stream receiving bottle- and keg-washing wastes with a BOD of 500 ppm from a brewery were controlled by the application of 20 to 30 lb granular $NaNO_3$ at 5 pold. points along the stream at 4-day intervals. Application of dissolved $NaNO_3$ was unsuccessful.—*CA*

Taste and Odor Control at Winterset, Iowa. W. Gordon. Taste & Odor Control J., **17**:6:1 ('51). The author gives an acct. of the control of tastes and odors at the water works at Winterset, Iowa. The water supply is an artificial lake impounding water from Cedar R. During summer, growth of algae is controlled by the addn. of copper sulfate. During the spring runoff, severe odors occur for 2–3 weeks but diminish when the supply is dild. by rain and melting snow. The water is treated with alum, carbon, chlorine, and lime and settled in an Accelator. After 1 hr the water is filtered on rapid sand filters and the effluent is chlorinated. When the plant first operated, no carbon was added, but tastes and odors necessitated this. Laboratory tests showed that the carbon was most effective at a low pH value, and it was added before the lime. Experience has shown that the point of

(*Continued on page 84*)

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(Continued from page 82)

application of the chemicals should, however, be varied according to the type of water being treated.—*WPA*

Combating Tastes and Odors Due to Algae. R. E. SIMONS. Taste & Odor Control J., **17**:3:2 ('51). The various methods of treatment used to reduce objectionable tastes and odors caused by the presence of algae in the water supply of Centralia, Ill., are described.—*WPA*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

Water and Sewage Plants to Get More Materials. Eng. News-Rec., **148**:15:42 (Apr. 10, '52).

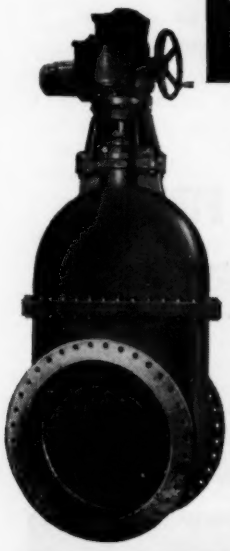
Use of DDT in the Control of Insect Carriers of Disease With Special Reference to Water Supplies and Sewage. F. C. BISHOPP. Proc. Ann. Conf. Md.-Del. W. & Sew. Assn., **19**:23 ('46).

Graphical Representation of Load on Polluted Streams. KARL IMHOFF. Sew. & Ind. Wastes, **22**:1614 ('50).

Ground Water Pollution in Michigan. NORMAN BILLINGS. Sew. & Ind. Wastes, **22**:1596 ('50).

Water Quality for Stationary Automatic Steam Generators. R. A. BARDWELL. Am. Ry. Eng. Assoc. Bul. **53**:497:272 ('51).

Developments in Water Technology as Applied to Steam Generation. R. T. HANLON. Modern Power & Eng., **45**:11:65 ('51).



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The Reading Meter

(*Continued from page 22*)

Water: A special editorial report. *Reprinted from the September 1952 issue of* Power. *McGraw-Hill Pub. Co., Inc., 330 W. 42nd St., New York 36, N.Y. (1952) 48 pp.; paperbound; $1.00*

If the ABC of H_2O does not eventually become absorbed by the water-using and water-abusing captains of industry, it will not be the fault of the country's publishers. In one of the best pictorial presentations yet, *Power* magazine has carefully sketched in an outline that should make at least the extent and scope of the water supply problem clear to those who cope with it. The balance between popular readability and technical integrity is for the most part carefully maintained, although some one seems to have lost his footing in the charting of the country's hydrologic conditions, with the result that only the most careful reader will be able to ascertain what a superficial glance should make obvious—the units in which the map divisions are calibrated. One excellent feature which should be noted is that which presents, in visible, graphic contrast, the ways in which dam regulation must vary, depending on the end in view—municipal supply, flood control, navigation, or power generation. The report proceeds from fundamentals to particulars, winding up with a discussion of matters industrialists are most immediately interested in—obtaining, processing, and conserving plant supplies.

Pacific Northwest Drainage Basins: *Summary report on water pollution. Water Pollution Series, No. 6; Public Health Service Pub. No. 87; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 79 pp.; paperbound; free*

The Pacific Northwest basin, without including the Canadian segment, comprises the state of Washington, most of Oregon and Idaho, part of Montana, and small portions of Wyoming, Utah, and Nevada. The development of low-cost hydroelectric power has given impetus to great industrial expansion and a population growth of one-third in the ten-year intercensus period. The present population is 4,600,000. Despite the high self-purification potential of the rapid streams, pollutional damage by industrial wastes and sewage has been severe, and many treatment facilities must be provided or improved.

(*Continued on page 88*)

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The Reading Meter

(*Continued from page 86*)

Water Pollution Research—1951. *Water Pollution Research Board, Dept. of Scientific & Industrial Research, London (1952) 56 pp.; paperbound; 2s. 6d. (about 35¢ U.S.) from H.M. Stationery Office, York House, Kingsway, London, W.C. 2, England*

This British agency's annual report includes an interesting report on the electrical treatment of boiler feedwater, and readers of the study by Eliassen & Uhlig published in the JOURNAL recently (*see* July issue, p. 576) might be interested in the somewhat negative findings. The research group decided that no really conclusive results could be obtained without prolonged study, and apparently it was felt that the time and facilities available would be more productively applied to other matters, for the research project was abandoned. Other subjects studied include the use of a flashing neon light as a continuous conductivity indicator, with possible application as a visible indicator of the dissolved solids content of softener effluents; the removal of radioactive contaminants by conventional sewage treatment; and various pollutional and sewage treatment topics.

California Drainage Basins: *Summary report on water pollution. Water Pollution Series, No. 5; Public Health Service Pub. No. 86; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 90 pp.; paperbound; free*

"Of the making of books there is no end," runs a favorite line of wearied readers, and books on the water problems of the West and Southwest merit honorable mention for their endlessness. This comparatively brief report adds its weight to the already imposing bulk.

Much of the interest and most of the problems involved in supplying California with water derive from the simple statistics of growth. In a state which suffers from poor natural distribution of what is any land's greatest liquid asset, a population of 1,500,000 at the turn of the century took the unlikely or at least inconsiderate course of multiplication. By 1950 the total had reached 10,500,000, and this amount represents a 52 per cent increase in the space of only ten years.

Interbasin transfer, greater reuse of water, and pollution control methods are recommended to stretch existing supplies. Additional efforts to coordinate administrative machinery, enlist popular support, and obtain needed data, are advocated by the study.

(*Continued on page 90*)



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EAST ORANGE, NEW JERSEY

The Reading Meter

(*Continued from page 88*)

Colorado River Drainage Basin: *Summary report on water pollution. Water Pollution Series, No. 9; Public Health Service Pub. No. 110; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 148 pp.; paperbound; free*

What is probably the most controversial watershed in the entire country seems to be blessed with a singular freedom from serious man-made pollution problems. Silting is a major threat, however, and menaces irrigation works as well as impounding resorvoirs and the great dams of the region. The freedom from articial pollution, at that, is only relative, and state agencies have requested construction of 34 new plants, additional treatment facilities at 31 plants, and the replacement of 53 others.

(*Continued on page 92*)

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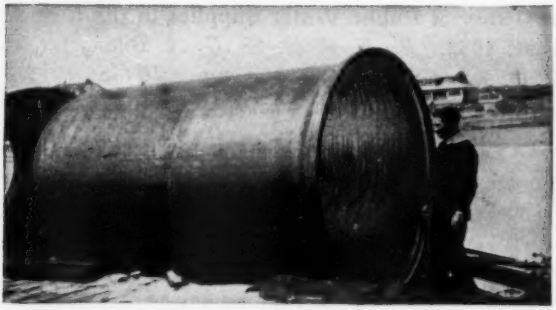
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The Reading Meter

(Continued from page 90)

The Industrial Utility of Public Water Supplies in the East South Central States, 1952. *By E. W. Lohr, G. A. Billingsley, J. W. Geurin, & W. L. Lamar. Circular 197, Geological Survey. Washington 25, D.C. (1952) 69 pp.; paperbound; free*

This useful aid to business men interested in plant location or, marketing surveys, contains a summary of basic information about the the public water supplies of 67 cities of the states of Alabama, Kentucky, Mississippi, and Tennessee. In addition to an outline of the ownership, source, treatment, and storage afforded by each water supply, chemical analyses are provided of both raw and finished waters.

The Industrial Utility of Public Water Supplies in the Mountain States, 1952. *E. W. Lohr, C. S. Howard, R. T. Kiser, J. D. Hem, & H. A. Swenson. Circular 203, Geological Survey, Washington 25, D.C. (1952) 79 pp.; paperbound; free*

Similar information and analysis are presented by this second of nine projected reports. The Mountain states covered by this report include Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.

The Industrial Utility of Public Water Supplies in the West North-Central States, 1952. *E. W. Lohr, P. C. Benedict, H. A. Swenson, & T. B. Dover. Circular 206, Geological Survey, Washington 25, D.C. (1952) 109 pp.; paperbound; free*

Further utility data and water supply analyses for the states of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

Air Diffusion in Sewage Works. *Manual of Practice No. 5, Federation of Sewage & Industrial Wastes Associations, 325 Illinois Bldg., Champaign, Ill. (1952) 75 pp.; paperbound; $1.25*

The result of a committee study that began ten years ago, this manual is the fifth in the series issued by FSIWA. Although directed to sewage works practice, some of the material may be useful to those interested in aeration as a water treatment method.

(Continued on page 94)

For the City of Jacksonville...



New McDuff Pumping Station, Constructed by Henry G. DuPree Co.

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The City of Jacksonville, Florida installed its first Simplex Type MO Venturi Meters back in 1925. Here's what Mr. C. H. Helwick, Superintendent of Jacksonville's Water Department, has to say about those original meters:

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No wonder, then, when consulting engineers Reynolds, Smith & Hills undertook the plans for Jacksonville's $7,000,000 water works improvement program, that Simplex Type MO Venturi Meters were specified as standard equipment for *all* pumping stations. For full information about MO and other Simplex meters write to Simplex Valve and Meter Company, Department 10, 6784 Upland Street, Philadelphia, Pa.

SIMPLEX

VALVE AND METER COMPANY

The Reading Meter

(*Continued from page 92*)

Surface Water Supply of Virginia: *Potomac, Rappahannock, and York River Basins, 1942–1950. Bul. 12, Div. of Water Resources, State Dept. of Conservation & Development, Charlottesville, Va. (1952) 372 pp.; paperbound; free*

The report presents a compilation of stream flow records made at all gaging stations for the eight-year period ending September 1950. It thus supplements Bul. 4, which published the 1927–1942 data. The present study includes two extreme years: 1947, among the lowest on record, and 1949, in which runoff was the highest on record for most streams. In addition, the flood of October 1942 in the Shenandoah and Rappahannock basins was the greatest since colonial times.

Chemical Quality of Surface Waters of Virginia, 1946–1948. *G. W. Whetstone & R. L. McAvoy. Bul. 11, Div. of Water Resources Dept. of Conservation & Development, Charlottesvile, Va. (1952) 38 pp.; paperbound; free*

Analyses of the chemical composition at various testing points are given, together with information on temperature, pH value, hardness, and BOD.

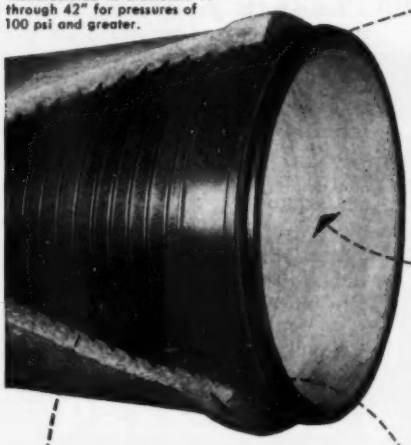
Water Resources of the Buffalo–Niagara Falls Region. *Charles W. Reck & Edward T. Simmons. Circular 173, Geological Survey, Washington 25, D.C. (1952) 26 pp.; paperbound; free*

It is refreshing to find, among the prophets of doom, waste, and scarcity whose publications sometimes seem to overwhelm this section of the JOURNAL, two geologists who calmly assert that the 125 bgd of water that drains from Lake Erie by way of the Niagara River to Lake Ontario is sufficient to supply 70 per cent of the *country's* present needs for all purposes except water power. Whatever reservations one may entertain about the continued adequacy of any quantity of water for a consuming public whose thirst seems to be stimulated rather than appeased by plenty, there seems little reason to question, at least for the forseeable future, the author's contention that "there should be no water shortage for the million or more people in the Buffalo–Niagara Falls area."

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Service Lines

Molecular filter membrane techniques for routine bacteriological tests by this new method are discussed in a bulletin issued by AG Chemical Co., Inc., Box 65C, Pasadena 6, Calif. A price list of Isopor filters and filter pads is included. Among matters discussed are sterilization procedures and the use of dehydrated nutrient schedules.

Air conditioning equipment operators should find interesting a leaflet entitled "Use of Water in Air-Conditioning Systems." Issued by Water Service Labs., Inc., 423 W. 126th St., New York 27, N.Y., the leaflet discusses corrosion, scale formation, and various remedies that can be applied.

Chemical feeding by means of the Heavy Duty Chemo-O-Feeder, an all-purpose chemical proportioning pump manufactured by Proportioneers, Inc., Box 1442, Providence 1, R.I., is the subject of an 8-page bulletin available from the company. Alternative methods of feeding are described and illustrated diagrammatically.

A liquid level control has been designed to operate by the action against a sensitized bellows unit of the varying air pressure required to maintain a constant, regulated flow of bubbles through the liquid. The bellows pressure sensing unit in turn actuates pump or valve motors. Known as the Bubbltrol, and featured in 8-page Bul. 1650 of Automatic Control Co., St. Paul 4, Minn., the instrument is said to offer the advantages of eliminating float or electrode maintenance.

Liquid strainers for pump intakes and other applications are described in a leaflet on the Ideal Liquid Strainer distributed by Golden-Anderson Valve Specialty Co., 2091 Keenan Bldg., Pittsburgh 22, Pa.

Four-cycle gas engines that use spark ignition and are totally enclosed against dust or other atmospheric contamination are the subject of an 8-page bulletin, "DDG Gas Engines," published by Worthington Corp., Harrison, N.J. Copies are being distributed in response to requests made on business stationery.

Insulating tapes—friction, rubber, and plastic—are the subject of a folder distributed by Ideal Industries, Inc., 1614 Park Ave., Sycamore, Ill. The plastic tape is said to provide both insulation and protection in a single application.



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Coming Meetings

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AWWA's 73rd Annual Conference

October 12–15—Southwest Section at Mayo Hotel, Tulsa. Secretary, Leslie A. Jackson, Mgr.-Engr., Munic. Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

October 21–22—Maritime Branch, Canadian Section, at Lord Beaverbrook Hotel, Fredericton, N.B. Secretary, J. D. Kline, Chief Engr., Public Service Com., Box 574, Halifax, N.S.

October 23–25—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

October 23–25—Iowa Section at Hotel Hanford, Mason City. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

October 28–31—California Section at Huntington Hotel, Pasadena. Secretary, John C. Luthin, Mgr. & Engr., Monterey Bay Water Co., 1113 Laurent St., Santa Cruz, Calif.

(*Continued on page 100*)

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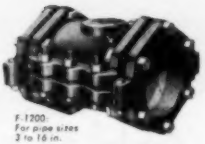
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Coming Meetings (contd.)—AWWA SECTIONS

October 29–31—Chesapeake Section at Wardman Park Hotel, Washington, D.C. Secretary, Carl J. Lauter, 6955 33rd St., Washington 15, D.C.

November 5–7—Virginia Section at Chamberlin Hotel, Old Point Comfort. Secretary, W. H. Shewbridge, Regional Engr., State Dept. of Health, 708 State Office Bldg., Richmond, Va.

November 10–12—North Carolina Section at Skyland Hotel, Hendersonville. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh, N.C.

November 16–19—Joint meeting of Alabama-Mississippi and Florida Sections of AWWA and Florida Sewage & Industrial Waste Assn., at San Carlos Hotel, Pensacola. Secretary, Alabama-Mississippi Section, Chas. W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala. Secretary, Florida Section, Marvin R. Boyce, Boyce Co., 504 Pennsylvania Ave., Clearwater, Fla.

December 4–6—Cuban Section in Havana. Secretary, Laurence H. Daniel, Pres., Laurence H. Daniel, Inc., Baratillo 9, Havana, Cuba.

OTHER ORGANIZATIONS

October 6–9—Federation of Sewage & Industrial Wastes Assns. Silver Anniversary Meteing at Hotel Statler, New York, N.Y. Reservations being handled directly by the hotel.

October 20–24—American Public Health Assn. Annual Conference at the Public Auditorium, Cleveland, Ohio. Details from Reginald M. Atwater, Exec. Secy., APHA, 1790 Broadway, New York, N.Y.

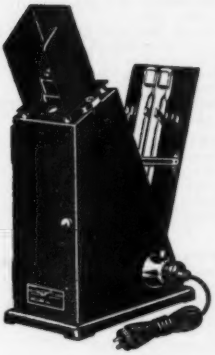
October 20–24—National Safety Congress at Chicago, Ill. Details from National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

November 16–19—Florida Sewage & Industrial Wastes Assn. (Joint meeting; see AWWA Alabama-Mississippi and Florida Sections.)

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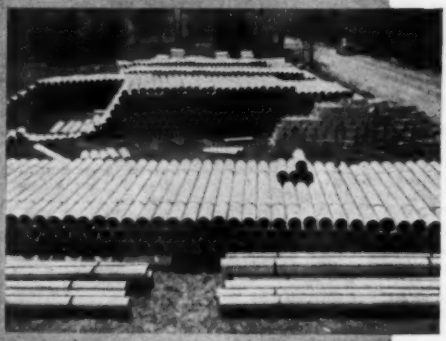
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A G Chemical Co., Inc. —
Ace Pipe Cleaning Contractors Co., Inc. —
Allis-Chalmers —
American Agricultural Chemical Co. 14
American Brass Co., The —
American Cast Iron Pipe Co. —
American Cyanamid Co., Industrial Chemicals Div. —
American Pipe & Construction Co. 95
American Well Works 75
Anthracite Equipment Corp. —
Armco Drainage & Metal Products, Inc. 53
Art Concrete Works —
Atlas Mineral Products Co., The —
Badger Meter Mfg. Co. —
Barrett Div., The —
Belco Industrial Equipment Div. 15
Bethlehem Steel Co. 37
Blockson Chemical Co. 9
Buffalo Meter Co. 36
Builders-Providence, Inc. 97
Burt, Leslie R., Co. —
Byron Jackson Co. —
Calgon, Inc. 79
Carborundum Co., The 61
Carlon Products Corp. 41
Carson, H. Y. 76
Cast Iron Pipe Research Assn., The 18–19
Centriline Corp. —
Chain Belt Co. 11
Chicago Bridge & Iron Co. —
Clow, James B., & Sons 99
Cochrane Corp. —
Crane Co. 77
Darley, W. S., & Co. 36
Darling Valve & Mfg. Co. 65
Dearborn Chemical Co. —
De Laval Steam Turbine Co. 39
Dorr Co., The Cover 3
Dresser Mfg. Div. —
Economy Pumps, Inc. —
Eddy Valve Co. 99
Electro Rust-Proofing Corp. 17
Ellis & Ford Mfg. Co. 8
Flexible Sewer-Rod Equipment Co. 57
Ford Meter Box Co., The 43
Foxboro Co., The —
General Chemical Div., Allied Chemical & Dye Corp. 87
Golden-Anderson Valve Specialty Co. —
Greenberg's, M., Sons —
Hammond Iron Works 33
Hays Mfg. Co. 103
Hellige, Inc. 101
Hersey Mfg. Co. 59
Hungerford & Terry, Inc. 52
Hydraulic Development Corp. 83
Industrial Chemical Sales Division, West Virginia Pulp & Paper Co. viii
Inertol Co., Inc. 67
Infilco Inc. 45
Iowa Valve Co. 99
Johns-Manville Corp. vi–vii
James Jones Co. 24
Keasbey & Mattison Co. 105
Kennedy Valve Mfg. Co., The —
Klett Mfg. Co. 58
Koppers Co., Inc. 13
Kupferle, John C., Foundry Co. —
Layne & Bowler, Inc. 73
Leadite Co., The Cover 4
Lock Joint Pipe Co. i
Lovell Chemical Co. —
M & H Valve & Fittings Co. 81
McWane Cast Iron Pipe Co. 47
Mueller Co. 69
National Cast Iron Pipe 99
National Water Main Cleaning Co. 107
Neptune Meter Co. iii
Northern Gravel Co. 72
Northrop & Co., Inc. 66
Omega Machine Co. (Div., Builders Iron Fdry.) —
Pacific States Cast Iron Pipe Co. 47
Peerless Pump Div. —
Pekrul Gate Div., (Morse Bros. Machinery Co.) —
Permutit Co. 49
Phelps Dodge Refining Corp. —
Philadelphia Gear Works, Inc. 84
Pitman Manufacturing Company 7
Pittsburgh-Des Moines Steel Co. 63
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.) 110
Pittsburgh Pipe Cleaner Co. 85
Pollard, Jos. G., Co., Inc. 4
Portland Cement Assn. 5
Proportioners, Inc. —
Refinite Corp. —
Reilly Tar & Chemical Corp. 109
Rensselaer Valve Co. 51
Riches-Nelson, Inc. 80
Roberts Filter Mfg. Co. —
Rockwell Mfg. Co. 110
Rohm & Haas Co. —
Ross Valve Mfg. Co. —
Simplex Valve & Meter Co. 93
Skinner, M. B., Co. —
Smith, A. P., Mfg. Co., The 89
Smith-Blair, Inc. —
Solvay Sales Div., Allied Chemical & Dye Corp. —
Sparling Meter Co., Inc. 48
Standard Electric Time Co. 23
Stuart Corp. 8
Tennessee Corp. 35, 76
U.S. Pipe & Foundry Co. v
Universal Concrete Pipe Co. 44
Walker Process Equipment, Inc. 55
Wallace & Tiernan Co., Inc. x, 71
Warren Foundry & Pipe Corp. 91
Well Machinery & Supply Co. 21
Welsbach Corp., Ozone Processes Div. 31
Wood, R. D., Co. Cover 2
Worthington Corp. —
Worthington-Gamon Meter Div. 3

Directory of Professional Services—pp. 25-29

Albright & Friel, Inc.
Alvord, Burdick & Howson
Bays, Carl A. & Assoc.
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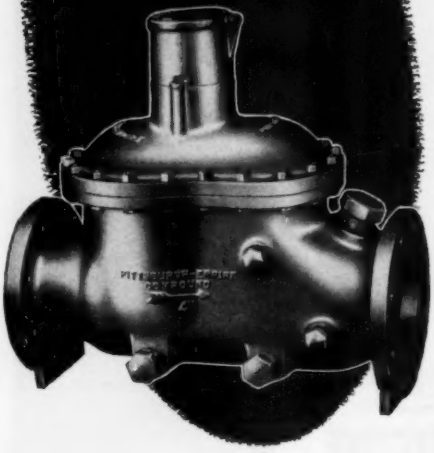

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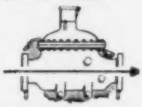
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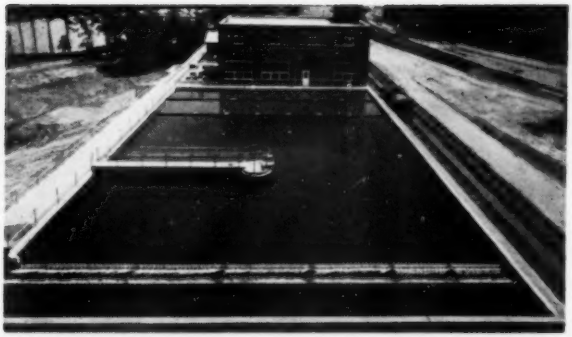
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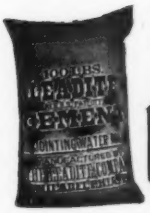
Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking

